EFFECT OF RICE HUSK ASH (RHA) ON THE COMPRESSIBILITY OF SOIL IN CHANGKAT CHERMIN, PERAK

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CIVIL ENGINEERING

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by

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the requirements for the
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CERTIFICATION OF APPROVAL

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TRONOH, PERAK

January 2008

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

MAS ELINA BINTI CHE JAMIL

ABSTRACT

This research presents a series of laboratory test to determine the effect of Rice Husk Ash (RHA) on the compressibility of soil in Changkat Cermin, Perak, Malaysia. This research proves that the compressibility characteristic of the soil changed with adding solely RHA because of interlocking between the soil and RHA particles. The concept can be seen through the particle size distribution curve. Different mixed were prepared by mixing RHA in percentages of 0 %(indicator), 12%, 18%, 24%, 30% and 36% with soil by weight. The blend of soil with 18% to 24% of RHA had resulted in decrease of void ratio, *e*, decrease of compression index, c_c, increase of coefficient of compressibility, c_v and decrease of the volume of compressibility, m_v. Compaction characteristic and Atterberg's limit were also determined. The addition of RHA with lime/cement increases the Optimum Moisture Content (OMC) and decreases the Maximum Dry Density (MDD).

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LL	:	Liquid Limit
MDD	:	Maximum Dry Density
OMC	:	Optimum Moisture Content
PI	:	Plasticity Index
PL	:	Plastic Limit
RHA	:	Rice Husk Ash
SG	:	Specific Gravity
e	:	void ratio
e_o	:	initial void ratio
C_c	:	compression index
C_v	:	coefficient of consolidation
H_{dr}	:	average longest path during consolidation
m_v	:	coefficient of volume compressibility
Sc	:	primary settlement
t	:	time for consolidation
T_v	:	time factor
V_s	:	volume of voids
V_v	:	volume of solids
Δe	:	change of void
ΔH	:	change of height
σ'	:	effective stress

APPENDICES

CHAPTER 1
INTRODUCTION

1.1 Background of study

Soft soil is the most widely encountered material during construction. Geotechnical Engineers all over the world face problems during the construction of foundation resting on these soils. These soils can only be used after stabilization.

Development in third world countries has called for new local material to replace cement, lime, bitumen, steel slag, fly ash, chemical compounds that is usually use for soil stabilization. The cost of these materials increase every year because of the demand. Investigations are done to local material for substitutes. One of the justifies substitute local material in Malaysia is rice husk.

Rahman,1987 stated that rice husk ash is another material that had been identified as soil stabililization and it is abundant because of its tough, woody, abrasive nature of the husks, low nutritive properties, resistance to weathering and high bulk and ash content.

There are many research conducted to examine the possibility to increase the strength and CBR value of the soil using Rice Husk Ash (RHA). Muntohar (1993) says that RHA can potentially stabilize the residual soil, either solely or mixed with cement. While Rahman (1986) stated in his research that RHA can be utilized as an alternative or a partial replacement of cement stabilizing lateritic soil and residual sand in order to reduce construction cost, particularly in the rural areas of developing countries.

1.2 Problem Statement

The characteristic of soil with high compressibility had incurred high construction cost. The focus of this project is to reduce the compressibility of soil. In present investigations fly ash had been use to improve the properties of the soil, however rice husk ash, the most abandoned material in Malaysia is said to have the same characteristic. It is suitable to use RHA as it can help to dispose the amount of rice husks by utilizing them as soil stabilizer.

1.3 Objective and Scope of Study

The objectives of this project are listed as follows:

- To determine the effect of RHA on compaction characteristic of the soil.
- To determine optimum percentage of RHA that reduces the compressibility of the soil.
- To determine the effect of RHA on the compressibility characteristics of the soil, such as void ratio, *e*, compression index, *Cc*, coefficient of consolidation, C_v, and coefficient of volume compressibility, m_v.

The research is based on lab testing. The scopes of studies of this project are listed as follow:

- To produce a laboratory specimens by mixing a certain amount of soil with Rice Husk Ash (RHA) at certain amount (% by weight).
- Sieve Analysis Test, Atterberg Limit Test, Standard Proctor Compaction Test and Oedometer Test on the mix were also conducted.

CHAPTER 2
LITERATURE REVIEW

2.1 Compressibility of Soil

According to Das (2004)

> A stress increase caused by the construction of foundations or other loads compresses soil layers. The compression is caused by
>
> a) deformation of soil particles.
> b) relocations of soil particles.
> c) expulsion of water or air from the void spaces.

Barnes (2000) stated that "compressibility has different concept from consolidation. Compressibility is volume changes in a soil when subjected to pressure that shows the amount of settlement. Volume changes occur because of changes in the volume of voids. While, consolidation is the rate of volume change with time that shows time to produce an amount of settlement required".

Barnes (2000) also stated that clay soils produce large amounts of settlements over a long period of time after the end of construction. The effect of settlement is more significant on clay. While, sand generally produces smaller amounts of settlements in much quicker time, settlement often occurs during the construction period.

2.1.1 The Process of Consolidation

Whitlow (1993) describe consolidation process as a process when a saturated mass of soil is loaded, such as by foundation. Immediate increase in pore water pressure occurs and hydraulic gradient is set up so that seepage flow takes place into surrounding soil. This excess pore pressure dissipates as water drains from the soil: very quickly in coarse soils (sand and gravels), and very slowly in fine soils (silts and clays) which have low permeability. As water dissipates from the soil, a change in volume occurs, the rate gradually reduce until steady state condition regained. Steady state is a condition that occurs when increase in effective stress $\Delta\sigma'$ is equal to the increase in total stress, and the excess pore water pressure has been reduced to zero. Figure 2.1 shows the stress-time curve of one dimensional consolidation.

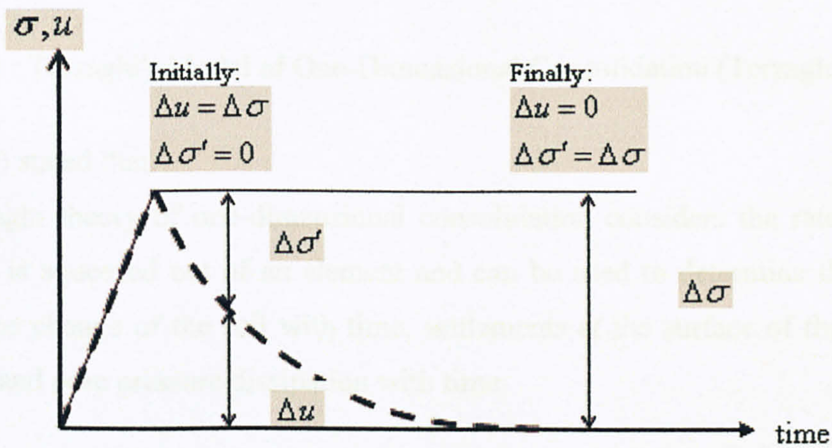

Figure 2. 1 : Stress-time curve of one dimensional consolidation (Whitlow, 1993)

Holtz and Kovacs (1981) pointed out that "surface settlements will results when the soil grains rearrange themselves into a more stable and denser configuration. The rate which water squeezed out of the pores when subjected to loading depends on the soil permeability". Terzaghi (1943) suggested a model shown in Figure 2.2 to illustrate one-dimensional consolidation, with steel spring to represent the soil. It is assumed that the frictionless piston is supported by the springs and the cylindrical is filled with water. When the load is applied, the water will dissipate out of the cylindrical through the valve. The rate of compression depends on the extent to which the valve is open. The valve open is analogous to the permeability of the soil.

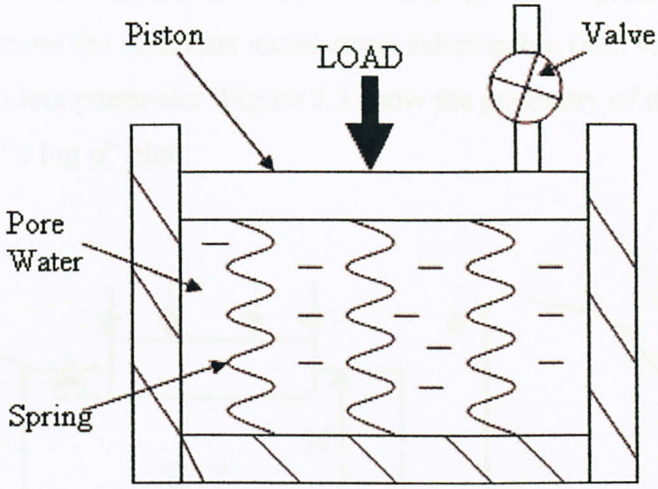

Figure 2. 2 : Terzaghi's Model of One-Dimensional Consolidation (Terzaghi, 1943)

Barnes (2000) stated that

> Terzaghi theory of one-dimensional consolidation considers the rate at which water is squeezed out of an element and can be used to determine the rates of volume change of the soil with time, settlements at the surface of the soil with time, and pore pressure dissipation with time.

2.1.2 Compressibility Characteristic

2.1.2.1 Compression index, Cc

Acccording to McPhail et. al (2004) , the slope, C_c, the compression index of the soil, is meant to represent the nonlinear stress-strain relationship (i.e., variable m_v) using a stress-independent parameter. Figure 2.3 show the geometry of the problem and cc on a conventional "e log p" plot.

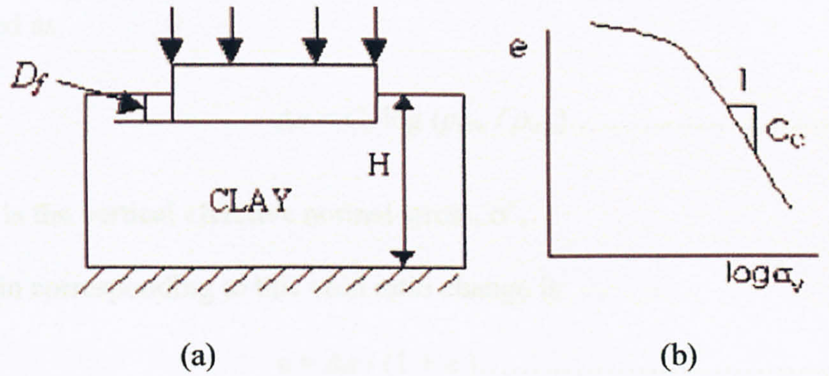

Figure 2. 3: (a) Geometry of the problem (one layer case shown)
(b) c_c on a conventional "e log p" plot

Plasticity and compressibility are typical properties of clays. Atterberg's limits of a clayey soil reflect the clay content and clay type of a soil. Compression index is also a clay dependent parameter. Among different correlations between the engineering and index properties of soils, which are often used to lessen the work load of a soil investigation program, "Skempton's relationship (1944) between compression index (C_c) and liquid limit (w_L) given as C_c=0.007(w_L-10) for the remoulded clays is well known. Another popular relationship between compression index and initial void ratio (e_0) has been proposed by Nishida (1956) that is Cc=1.15 (eo-0.27). There are similar other relationship given by different researchers, but the use of plasticity index, I_P in the prediction of C_c is scarce" (Amit Nath et. al, 2004). Figure 2.4 shows the variation of Liquid Limit(w_L), Plasticity Index (I_p) and Compression Index(c_c) with kaolin Fraction (c).

2.1.2.2 Void ratio, e

Das (2004) define void ratio as the ratio of the volume of voids to volume of solids.

$$e = \frac{V_v}{V_s} \quad \text{.......................................} \quad (2.1)$$

According to Whitlow (2001) void ratio can be obtained by multiplying the specific gravity of the soil with moisture content.

$$e = Gsw \quad \text{.......................................} \quad (2.2)$$

McPhail et. al (2004),indicate that using the slope C_c, the void ratio change corresponding to an effective stress change from an old value to a new value can be calculated as:

$$\Delta e = C_c \log (p_{NEW} / p_{OLD}) \quad \text{.......................................} \quad (2.3)$$

where p is the vertical effective normal stress, σ'_v.

The strain corresponding to this void ratio change is:

$$\varepsilon = \Delta e / (1 + e) \quad \text{.......................................} \quad (2.4)$$

2.1.2.3 Coefficient of volume compressibility, m_v

Whitlow (2001) defines coefficient of volume compressibility as" the amount of change in unit volume due to increase in effective stress. The value of m_v is not constant but varies with the level of effective stress. Oedometer test results can be used to obtain a range of m_v values".

$$S_c = \Delta H = m_v \Delta\sigma' H_o \quad \text{.......................................} \quad (2.5)$$

$$m_v = \frac{\Delta H}{\Delta\sigma'} \quad \text{.......................................} \quad (2.6)$$

But $$\frac{\Delta H}{H} = \frac{\Delta e}{1 + e_o} \quad \text{.......................................} \quad (2.7)$$

Therefore $$m_v = \frac{\Delta e}{\Delta\sigma'} \frac{1}{1 + e_o} \quad \text{.......................................} \quad (2.8)$$

Where $\Delta e / \Delta\sigma'$ = slope of the e / σ' curve

2.1.2.4 Coefficient of consolidation, c_v

Coefficient of consolidation, c_v is used determine the rate of consolidation of soil. Terzaghi (1925) had proposed theory to consider the rate of one dimensional consolidation for saturated clay. The mathematical derivations are based on six assumptions:

1) The clay-water is homogenous.
2) Saturation is complete.
3) Compressibility is negligible.
4) Compressibility of soil grains is negligible (but soil grains rearrange).
5) The flow of water is in one direction only (in the direction of compression).
6) Darcy's law is valid.

Terzaghi's came out with mathematical equation to calculate the rate of consolidation.

$$T_v = \frac{c_v t}{H^2_{dr}} \quad \text{...} \quad (2.9)$$

Coefficient of consolidation, c_v can be obtained from two method: logarithm-of-time method proposed by Casagrande and Fadum (1940) and square-root-of time method proposed by Taylor (1942). This c_v for both methods is given by the measurement device that read the oedometer gauge.

2.2 Stabilization of Soil

"Soil stabilization is the alteration of any property of a soil to improve its engineering performance" (T.William Lambe, 1969). It is used to treat the soil to provide a stable or a working platform for construction. There are two types of soil stabilization that are mechanical process and chemical process.

2.2.1 Mechanical Process

"This is a process of altering soil properties where energy is applied by changing the gradation through mixing with other soil, densifying the soils using compaction, or undercutting the existing soils and replacing them with granular material" (Department of Transportation Indiana, 2002).

2.2.2 Chemical Process

"The transformation of soil index properties by adding chemicals such as cement, fly ash, lime, or a combination of these, often alter the physical and chemical properties of the soil including the cementation of the soil particles"(Department of Transportation Indiana,2002).

It is important to differentiate soil stabilization process that changes physical or chemical properties of soil. White (1995) indicates that soil stabilization by chemical process can be divided into two:

1. Physical Properties

The addition of RHA would fill in the intervoid of the granulated soil particles. The additive will fill the pore and bind the soil particle together. This phenomenon was also depicted by Bell (1996).

2. Chemical Properties

Calcium hydroxide, Ca $(OH)_2$ from hydration process between water and lime/cement reacts with soil. The Calcium hydroxide, Ca $(OH)_2$ will be adsorbed by soil component in cation exchange to form calcium silicate gel. It is form from the hydration of anhydrous calcium silicate cement. When rice husk was allowed to burn under controlled temperature, higher pozzolanic properties (than other leaf plants) were observed. Silica is a main mineral of RHA. Due to the pozzolanic reaction between soil and Rice Husk Ash (RHA), two materials can be produced that is calcium silicate hydrates and calcium aluminate hydrates depending on soil contents. Pozzolanic reaction will occur with the existance of CaO from Rice Husk Ash (RHA).

A.S Muntohar (2000) indicate that "lime reacts with any other fine pozzolanic component (such as hydrous silica and RHA minerals) to form calcium-silicate cement with soil particles. This reaction is also water insoluble. The cementing agents are exactly the same for ordinary Portland Cement. The difference is that the calcium silicate gel is formed from the hydration of anhydrous calcium silicate (cement), whereas with the lime, the gel is formed only by the removal of silica from the clay minerals of the soil. Figure 2.5 shows the reaction mechanism between lime-rice husk ash (LRHA) with soil".

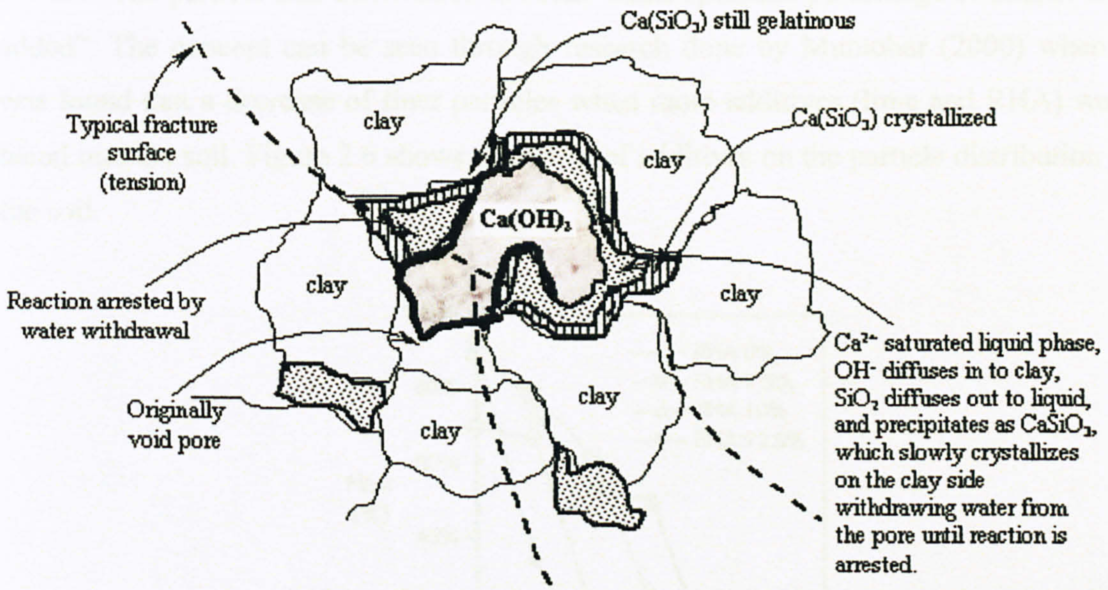

Figure 2. 4: Reaction mechanism of stabilization on clay soils (Muntohar, 2000)

According to Deng-Fong Lin et. al (2006), the pozzolanic chemical equations are described as:

$$Ca(OH)_2 + SiO_2 \longrightarrow \text{C-S-H gel (calcium silicate hydrates)}$$
$$Ca(OH)_2 + Al_2O_3 \longrightarrow \text{C-A-H gel (aluminum silicate hydrates)}$$

This research is done by adding solely RHA. Both chemical reaction that will alter physical and chemical properties of the soil occur. However, only small amount of chemical properties alteration will occur as the amount of CaO content in RHA is too small. This means, the major alteration will only change the physical properties of the soil.

2.2.3 Effect of RHA on Particles Size Distribution of the Soil

As indicated by White (1995), that "additive will act as a filler to fill the pore and bind the soil together, it is done by chemical process but alter only the physical properties of the soil. The particle size distribution is better when optimum percentage of additives is added". The concept can be seen through research done by Muntohar (2000) when it was found that a decrease of finer particles when more additives (lime and RHA) were blend into the soil. Figure 2.6 shows the effect of additives on the particle distribution of the soil.

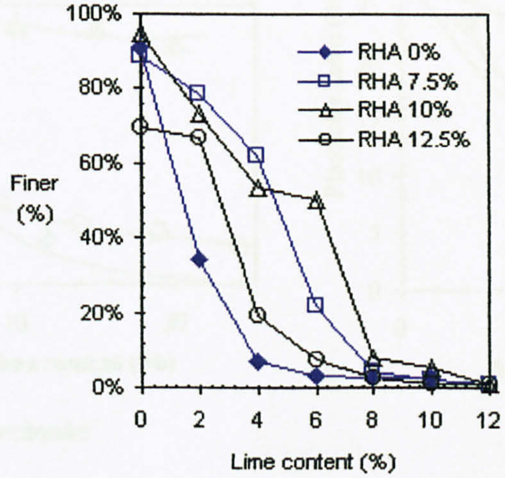

Figure 2. 5: Effect of additives on particle size distribution of the soil (Muntohar, 2000)

2.2.4 Effect of RHA on Atterberg's Limit of the Soil

Plasticity Index (PI) indicates the range of moisture content over which material exists in a plastic condition (Fred G.Bell, 1994). Table 2.1 shows the plasticity of soils by Skempton (1953):

Table 2. 1 : Plasticity of Soil (after Anon,1979)

Class	Plasticity index (%)	Description
1	Less than 1	Non-Plastic
2	1-7	Slightly plastic
3	7-17	Moderate plastic
4	17-35	Highly plastic
5	Over 35	Extremely plastic

Figure 2.7 shows the effect of various percentages of additives on the plasticity of kaolin and bentonite done by Muntohar et. al (2003). According to Muntohar et. al (2003), the cement and RHA had reduce the plasticity of the residual soil with 6%-8% of cement and 12%-15% RHA which indicate an improvement of soil behavior.

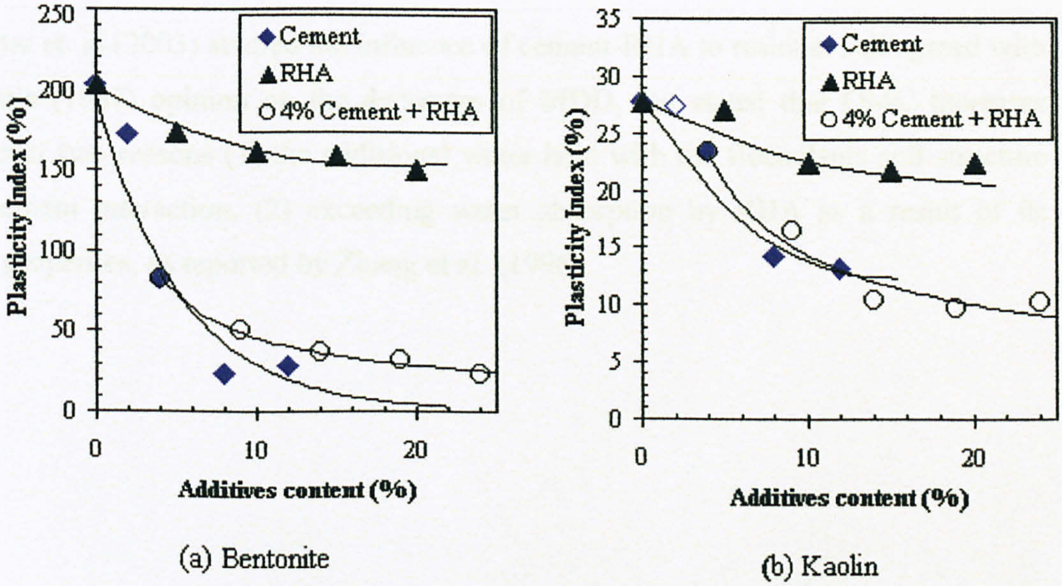

Figure 2. 6: Effect of various percentage of additives on plasticity of kaolin and bentonite (Muntohar et. al, 2003)

2.2.5 Effect of RHA on the Compaction Characteristic of the Soil

Whitlow (2002) indicates that compaction settlement may occur due to traffic movement, heavy machinery and certain construction management such as pile-drying.

"Compaction is the densification of soils by the application of mechanical energy. It also involves a modification of the water content as well as the gradation of the soil" (Holtz and Kovacs, 1981). R.R Proctor in the early 1930's established that compaction is a function of four variables: (1) dry density ρ_d, (2) water content w, (3) compactive effort, (4) soil type gradation (gradation, presence of clay mineral, etc).

Rahman (1987) in his research to study the influence of RHA on residual sand, stated that increase in dry density is an indicator of improvement. MDD decreases because the specific gravity of the rice husk ash is lower compared to soil grains and ash raises air bubbles when mixed with soil. The OMC increases due to the pozzolanic reaction of the ash with the soil constituents. Rahman (1987) in other research, where he studied the effects of cement-RHA mixtures on lateritic soil, stated that the MDD decreases because of both grain size distribution and specific gravity of the soil and stabilizers.

Muntohar et. al (2003) studied the influence of cement-RHA to residual soil agreed with Rahman's (1987) opinion on the decreases of MDD, but stated that OMC increases because of two reasons (1) the additional water held with the flocculants soil structure from cement interaction, (2) exceeding water absorption by RHA as a result of its porous properties, as reported by Zhang et al. (1996).

2.2.6 Effect of RHA on the Compressibility Characteristics of the Soil

Phani et. al (2001) in his research indicate that "fly-ash-treated clays undergo less compressibility. Compression index, c_c of the composite soil decreases indicating improvement in compressibility characteristics. Coefficient of consolidation,c_v, also decreases with increase in percent fly ash".

While Muntohar (1999) had done an investigation on the influence of RHA and lime on engineering properties of clayey subgrade. At lime-rice husk ask (LRHA), 6% to 10%, consolidation settlement was lowered from 0.03 to 0.006. Both researches had applied the chemical process reaction between the soil and additives that is known as pozzolanic reaction to stabilize the soil. This process is discussed in detail in Section 2.2.2: Chemical Process in this report.

2.3 Rice Husk Ash

Rice husk ash is a pozzolanic material that has potential to be used in Malaysia to substitute conventional material that is already used for soil stabilization. In Malaysia, rice husk is sufficiently produce and abundant because it is difficult to dispose or utilize this low-value by-product. "The rice husks are tough, woody, abrasive husks, low nutritive properties, high resistance to weathering, high bulk and ash content" (Subramanian, 1988). Rice husks is either burnt or dumped as a waste. Table below shows the production of rice husk in Malaysia from year 1985 to 2000 given by Food and Agriculture Organization of the United Nations (FAO)

	1985	1990	1995	1998	1999	2000
RICE						
Area Harv (Ha)	654,974	680,647	672,787	674,404	692,389	692,389
Yield (Hg/Ha)	26,648	27,694	31,619	28,829	29,415	29,415
Production (Mt)	1,745,367	1,884,984	2,127,271	1,944,240	2,036,641	2,036,641
Rice Imports - Qty (Mt)	428,017	330,336	427,556	657,870	612,467	NA
Paddy Imports - Qty (Mt)	NA	NA	NA	NA	NA	NA
Rice Exports - Qty (Mt)	2,002	111	2,430	2,088	117	NA
Paddy Exports - Qty (Mt)	0	0	24	NA	NA	NA
OTHERS						
Population-EstimatesTotal (1000)	15,677	17,845	20,108	21,410	21,830	NA
Population-Estimates Agr Pop (1000)	5,006	4,646	4,314	4,089	4,011	NA
Agricultural Area (1000Ha)	5,798	7,176	7,885	7,890	NA	NA
irrigation - Agricultural Area (1000Ha)	334	335	363	365	NA	NA
Total Fertilizers Consumption (Mt)	611,400	951,500	1,087,000	1,406,111	NA	NA
Tractors Agric Total In Use (Number)	12,000	26,000	43,295	43,300	NA	NA

Table 2. 2 : Production of Rice Husk in Malaysia from year 1985 to 2000 given by Food and Agriculture Organization of the United Nations (FAO)

Rice milling generates a by-product known as husk. The husk surrounds the paddy grain. During milling of paddy, the husk is removed, about 78 % of weight is received as rice, broken rice and bran. Rest 22 % of the weight of paddy is received as husk. This husk is used as fuel in the rice mills to generate steam for the parboiling process. This husk contains about 75 % organic volatile matter and the balance 25 % of the weight of this husk is converted into ash during the firing process, is known as rice husk ash (RHA). This RHA in turn contains around 85 % - 90 % amorphous silica. Therefore, for every 1000 kgs of paddy milled, about 220 kgs (22 %) of husk is produced, and when this husk is burnt in the boilers, about 55 kgs (25 %) of RHA is generated". (Maeda et. al 2001).

According to Z.Ramli et. al (2003) :

> RHA is a general term describing all types of ash produced from burning rice husks. In practice, the type of ash varies according to the burning technique. The silica in the ash undergoes structural transformations depending on the conditions (time, temperature, etc) of combustion. At 550-800°C amorphous ash is formed and at temperature greater than this, crystalline ash is formed. These types of silica have different properties and it is important to produce ash of the correct specification for the particular end use.

Lime-rice husk ash mixture was used in stabilization of deltaic clays by Lazaro and Moh (1970). Lazaro and Moh (1970) concluded that effective improvement of soil could be achieved by RHA. Muntohar, 2000 suggested that the percentage of rice husk ash are 0%,4%,8%,12%,16%,20%, while Rahman, 1987 suggested that the percentage of rice husk are 7.5%,10% and 12.5%. The value of both research range from 0% to 20%.However, the percentage of rice husk use in this research are taken from 0% to 42% considering no adding of lime or cement.

Muntohar (2000) has established that clayey subgrade properties can be improved by adding RHA and lime. A.S Muntohar (2004) repeated that "the RHA was obtained by burning the rice husk in incinerator. According to XRF Test (Muntohar, 2004) the major chemicals composition of the RHA was 88% of Silica Oxides (SiO2) and loss of ignition was 4.8%".

Table 2.3 shows the chemical composition of RHA given by Lazaro & Mohr (1970) and A.S Muntohar (1987).

Table 2. 3 : Chemical composition of Rice Husk Ash (RHA)

Chemical elements	Chemical Composition(%)	
	Lazaro & Moh (Thailand)	Agus Setyo Muntahor (Indonesia)
SiO_2	88.66	89.08
CaO	0.75	1.29
MgO	3.53	0.64
Na_2O	-	0.85
K_2O	-	1.38
Fe_2O_3	0.36	0.78
P_2O_5	-	0.61
Al_2O_3	1.48	1.75
MnO_2	-	0.14
CO_2	0.51	-
HD	-	2.05
Loss on ignition	3.80	4.8

CHAPTER 3
METHODOLOGY

The project was done based on lab testing. There were basically four major tests being done on the mixed of RHA and soil. Figure 3.1 shows the overall methodology for the research:

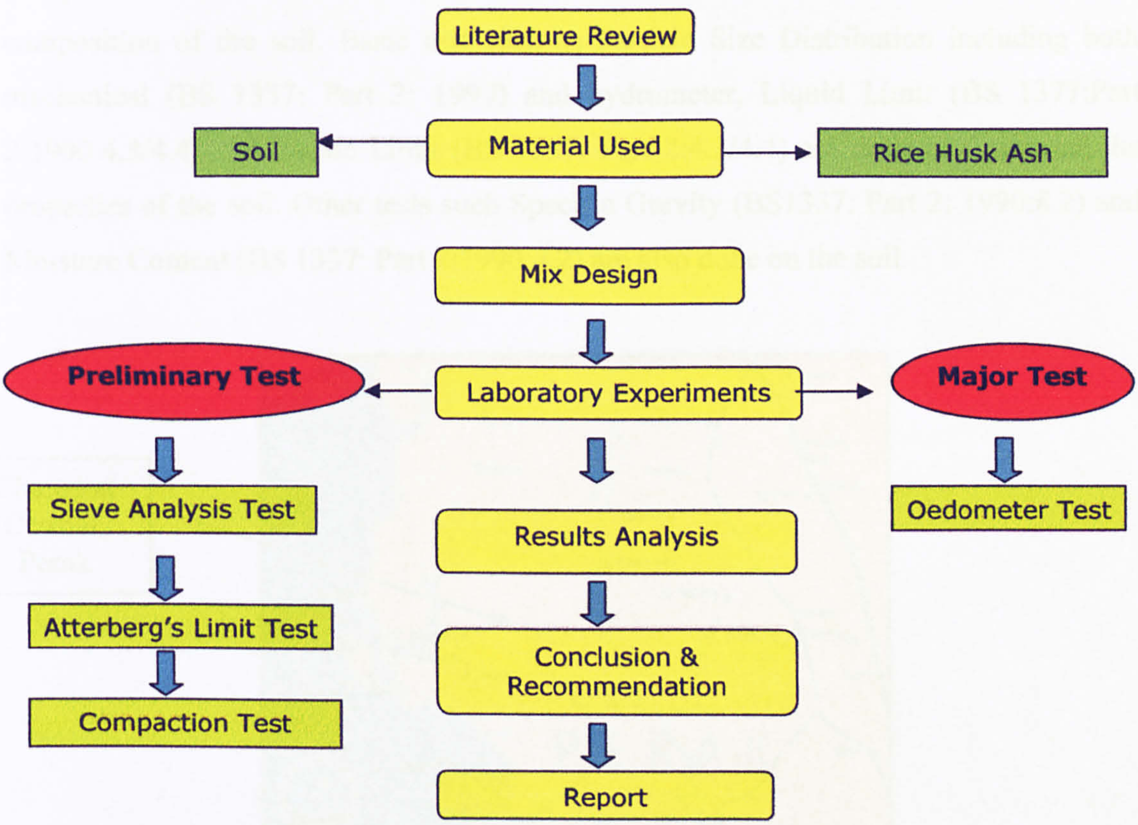

Figure 3. 1 : Overall methodology of the project

3.1 Materials Used

3.1.1 Soil Samples

Soil samples used in this research was collected from Changkat Chermin, Ayer Tawar, Perak. Figure 3.1 shows the location of soil sample collected. The soil was first dry in the oven for one day before being sieved. Only the soil passing 425 μm sieve was used for test, which means only fine soil was selected.

X-ray Diffraction Test was done to know the chemical element and chemical composition of the soil. Basic test such as Particle Size Distribution including both mechanical (BS 1337: Part 2: 1990) and hydrometer, Liquid Limit (BS 1377:Part 2:1990:4.3/4.4) and Plastic Limit (BS 1337: Part 2:4.3/4.4) are done to determine the properties of the soil. Other tests such Specific Gravity (BS1337: Part 2: 1990:8.2) and Moisture Content (BS 1337: Part 2:1990:3.2) are also done on the soil.

Figure 3. 2 : Location of Changkat Cermin, Ayer Tawar, Perak

3.1.2 Rice husk ash

The rice husks in this research were collected from BERNAS, Manjung, Perak. Specific Gravity Test was done on the RHA according to Specific Gravity (BS1337: Part 2: 1990:8.2). It was burned at 300°C to obtain the ash by using incinerator. An amount of 5kg RHA was grounded by 12 mild steel balls in the Los Angeles Abrasion machine. The grinding took half an hour to equal 999 revolutions. This period produces suitable fines and proper surface area. The ground RHA was then transferred into a plastic tank and stored in the airtight container at room temperature to prevent atmospheric humidity absorption. Only RHA passing 425 μm sieve is used in this research. Figure 3.4 shows the step to prepare RHA that was being used in the project.

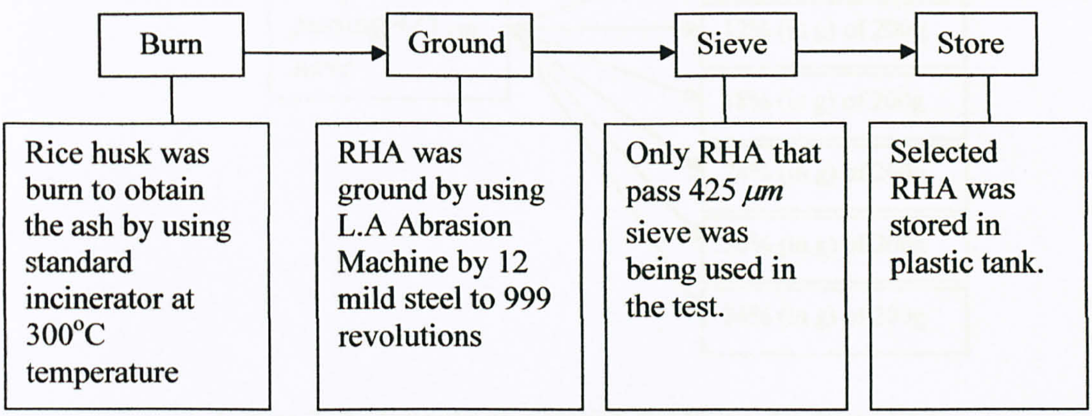

Figure 3. 3 : Preparation of RHA

The percentages of RHA used are 0 %(as an indicator), 12%, 18%, 24%, 30%, and 36%.The percentages are selected based on previous research done by Agus Setyo Muntohar, 2000 and Md. Anisur Rahman, 1987.

3.2 Laboratory Tests

3.2.1 Sieve Analysis Test

The Sieve Analysis Test was determined according to BS 1377: Part 2:1990. The tests were carried out by mixing soil with various percentages of RHA. An amount of 200g soil was mixed with 0 % (as an indicator), 12%, 18%, 24%, 30% and 36%. Figure 3.5 shows sample preparation for sieve analysis test.

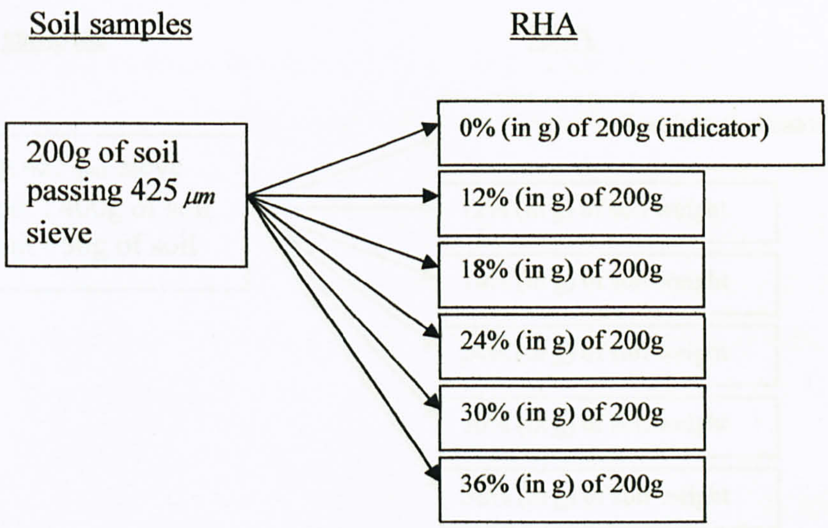

Figure 3. 4 : Sample preparation for Sieve Analysis Test

3.2.2 Atterberg Limit Tests

The Atterberg Limits were determined according to BS 1337/Part 2:4.3/4.4 for determining liquid limit, plastic limit and plasticity index. Only RHA passing 425 μm sieve were used in this research while others were rejected. The tests were carried out by adding various percentages of RHA with also 425 μm sieve soil. Figure 3.6 shows the sample preparation for Plastic Limit Test and Plastic Limit Test.

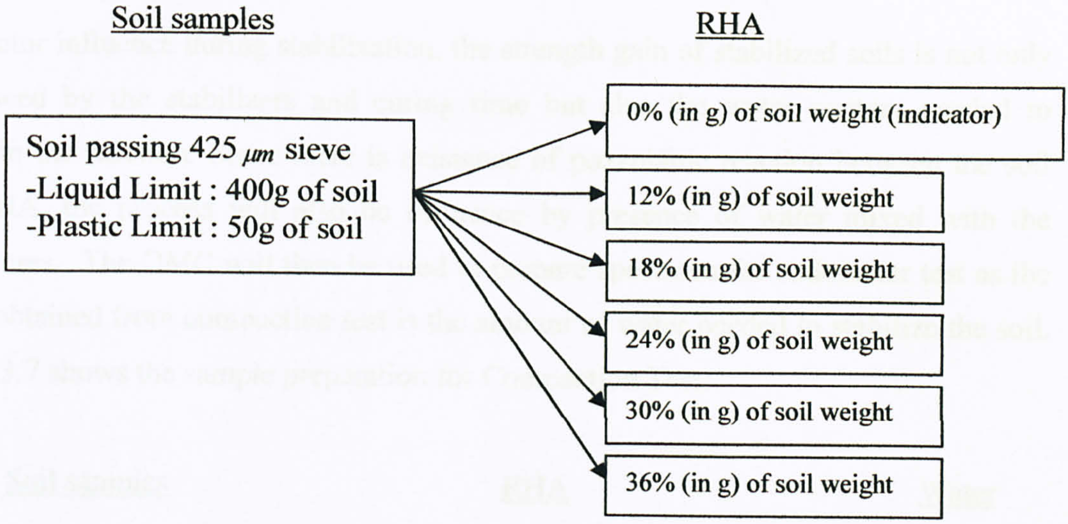

Figure 3. 5 : Sample Preparation for Liquid Limit Test and Plastic Limit Test

3.2.3 Compaction Tests

Proctor Standard Compaction Test was done according to BS 1377: Part 2: 1990:4.3/4.4 to determine the Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) of the soils. The soil and RHA were mixed thoroughly with different water content ranging form 9% to 54% with increment of 3% of water for every compaction stage.

All specimen related to this area of studies were prepared based on the amount of on their OMC for each test.

The factor influence during stabilization, the strength gain of stabilized soils is not only influenced by the stabilizers and curing time but also the water content needed to maintain the reaction. Since there is existence of pozzolanic reaction between the soil and RHA, the process will also be influence by presence of water mixed with the admixtures. The OMC will then be used to prepare specimen for oedometer test as the OMC obtained from compaction test is the amount of water needed to stabilize the soil. Figure 3.7 shows the sample preparation for Compaction Test.

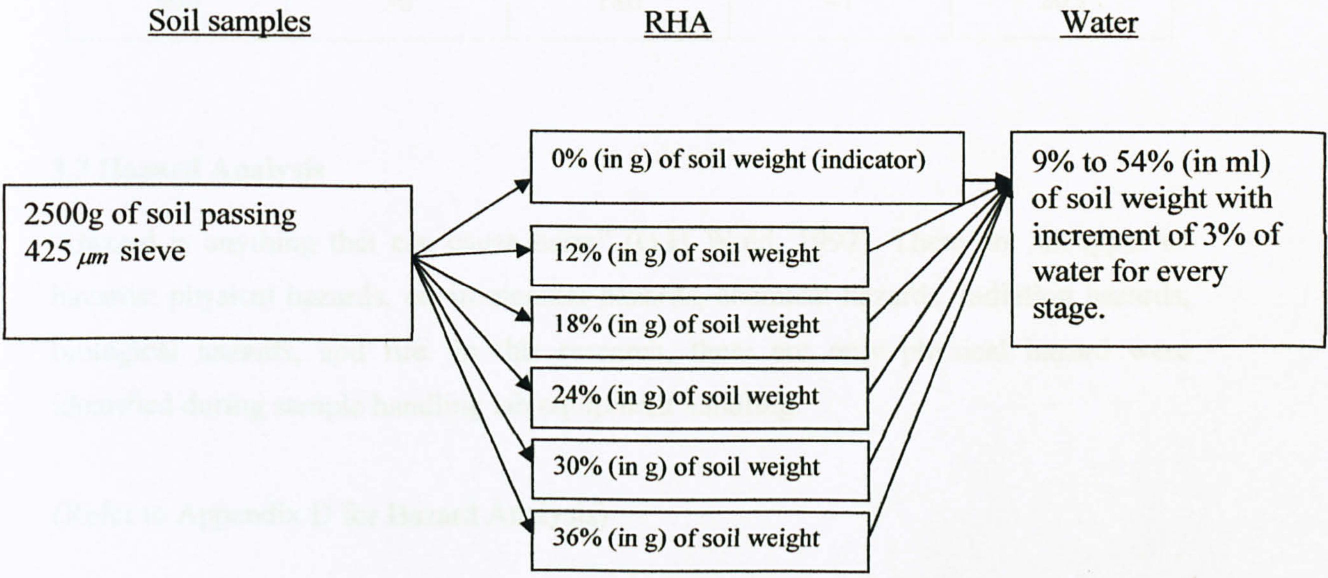

Figure 3. 6 : Sample preparation for Compaction Test

3.2.4 Oedometer Test

Oedometer Test was done according to BS 1377: Part 5 to determine the compressibility characteristics of the soils. The tests were carried by mixing various percentage of RHA with soil. The soil was first compacted by using by Proctor Compactor with adding OMC obtain from compaction test. The compaction work was done to stabilize the mixed. Table 3.1 shows the sample preparation for Oedometer Test.

Table 3. 1 : Sample preparation for Oedometer Test

Soil (g)	RHA		Water	
	(%) weight of soil	(g)	(%) weight of soil	(ml)
500	0	0	20.5	102.5
500	12	60	26	130
500	18	90	29.5	147.5
500	24	120	30.5	152.5
500	30	150	36	180
500	36	180	41	205

3.3 Hazard Analysis

"Hazard is anything that can cause harm" (G.H Wold, 1997). There are six types of hazards: physical hazards, environmental hazards, chemical hazards, radiation hazards, biological hazards, and fire. In this research, there are only physical hazard were identified during sample handling lab equipment handling.

(Refer to Appendix D for Hazard Analysis)

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Properties of Soil

4.1.1 Chemical Properties of Soil

4.1.1.1 X-Ray Diffraction Test

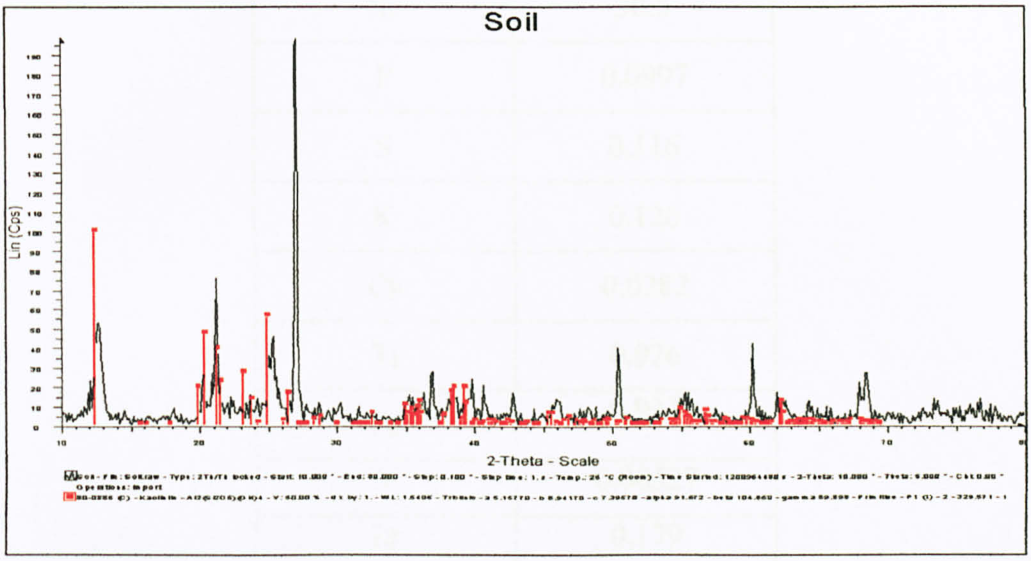

Figure 4. 1 : Difragtograph of Soil

Figure 4.1 shows the Diffragtoraph of the soil sample. Kaolinite clay mineral is identified in the soil by a strong diffraction line.

4.1.1.2 X-Ray Fluorescence Test

Table 4. 1 : Soil Chemical Element

Element	Quantity (%)
Mg	0.0444
Al	16.2
Si	30.5
P	0.0997
S	0.116
K	0.126
Ca	0.0282
Ti	0.926
Fe	0.933
Y	0.00527
Zr	0.179
Nb	0.0108
Re	0.115
Compton	1.01
Reyleigh	1.64
Norm	100.00

Table 4. 2 : Soil Chemical Composition

Element	Quantity (%)
MgO	0.0736
Al_2O3	30.6
SiO_2	65.2
P_2O_5	0.229
SO_3	0.290
K_2O	0.152
CaO	0.0394
TiO_2	1.54
Fe2O0	1.33
Y_2O_3	0.00670
ZrO_2	0.241
Nb_2O_5	0.0155
Re	0.115
Compton	1.01
Reyleigh	1.64
Norm	100.00

From the results, the soil sample have high silica content. From Table 4.1: Soil Element, Silica (Si) content is 30.5%, while from the Table 4.2: Soil Composition; the Silica Oxide (SiO_2) content is 65.2%. Both tables have shown high content of Silica that will react with Ca (OH_2) from Rice Husk Ash (RHA).

4.1.2 Physical Properties of Soil

Table 4. 3 : Physical Properties of Soil

Properties	Values
Moisture Content	29.43%
Liquid Limit	50.6%
Plastic Limit	26.96%
Plasticity Index	23.64%
Specific Gravity	2.53

(Refer to Appendix A for Details of Lab testing for Soil and RHA Physical Properties)

4.1.3 Sieve Analysis Test

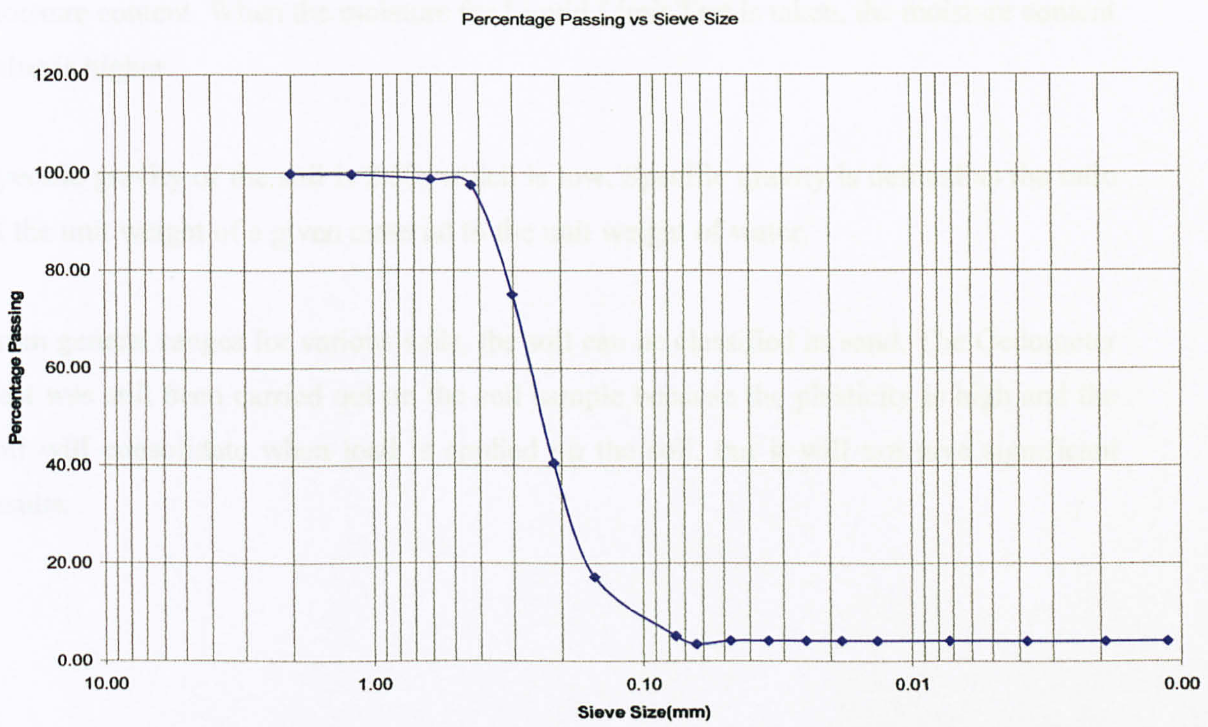

Figure 4. 2 : Graph of Percentage Passing vs Sieze Size

Figure 4.2 shows the Graph of Percentage Passing vs Sieve Size. The curve shows that that the soil is poorly graded. The percentage of sand is 94.97%, while the percentage of silt and clay is 5.03%.

Table 4.3 shows the physical properties of the soil. Liquid limit of the soil is 50.60%. The soils have high plasticity because the liquid limit is more than 50.The Plastic Limit of the soil is 26.96%.From the result, plasticity index is 23.64%. Burmister (1949) classified this soil as high plasticity. From Atterberg's Limit results and Sieve Analysis results, Unified Soil Classification System (USCS) classified the soil as SANDY Clay.

From the test carried out, moisture content is 29.43%.The test is done immediately after taking the sample. The moisture content is low because the soil sample is taken from excavated soil that already been abundant for several months on the ground surface. Effects like evaporation and drainage of water from the soil had reduced the natural moisture content. When the moisture for Liquid Limit Test is taken, the moisture content value is higher.

Specific gravity of the soil is 2.53, which is low. Specific gravity is defined as the ratio of the unit weight of a given material to the unit weight of water.

From general ranges for various soils, the soil can be classified as sand. The Oedometer Test was still been carried out on the soil sample because the plasticity is high and the soil will consolidate when load is applied on the soil, but it will not give significant results.

4.2 Properties of Rice Husk Ash (RHA)

4.2.1 Chemical Properties of Rice Husk Ash (RHA)

4.2.1.1 X-Ray Fluorescence Test for RHA

Table 4. 4 : RHA Chemical Element

Element	Quantity (%)
O	45.6
Si	35.4
P	0.849
K	7.98
Ca	1.66
Fe	1.22
Re	3.71
Mg	-
Al	-
S	-
Cl	-
Mn	-
Compton	0.61
Reyleigh	1.07
Norm	100.00

Table 4. 5 : RHA Chemical Composition

Element	Quantity (%)
SiO_2	75.8
P_2O_5	1.94
K_2O	9.62
CaO	2.33
Fe_2O_3	1.75
Re	3.71
MgO	-
Al_2O_3	-
SO_3	-
Cl	-
MnO	-
Compton	0.61
Reyleigh	1.07
Norm	100.00

From Table 4.4 Rice Husk Ash (RHA) Element and Table 4.5 Rice Husk Ash (RHA) Chemical Composition we can see that RHA that was burnt at 300°C contain high Calcium Oxide, CaO that is 2.33% compare to 500°C as indicated by A.S Muntohar, 2000, that only contain 0.75% Calcium oxide,CaO. While the Silica Oxide, SiO2 for RHA burn at 300°C is less (75.8%) than RHA that was burnt at 500°C (89.08%). The Calcium Oxide, CaO will react with water be hydrated to produce Calcium hydroxide $(Ca(OH)_2$. The hydrated Calcium Hydroxide will react with Silica Oxide, SiO_2 from soil and produce cementatious product. So, the RHA that contain high Calcium Oxide that is at temperature 300°C is use in this research, higher content of Calcium Oxide will enhance pozzolanic reaction.

4.2.2 Physical properties of Rice Husk Ash (RHA)

4.2.2.1 Specific Gravity of RHA

Table 4. 6 : Specific Gravity of RHA

Properties	Values
Specific Gravity	2.43

From Table 4.6: Specific Gravity of RHA sample, the specific gravity of RHA is 2.43, which is lower than specific gravity of the soil. Specific gravity is defined as the ratio of the unit weight of a given material to the unit weight of water.

From general ranges for various soils, the RHA can be classified as sand.

4.3 Effect of Various Percentages of RHA on Particle Size Distribution of the Soil

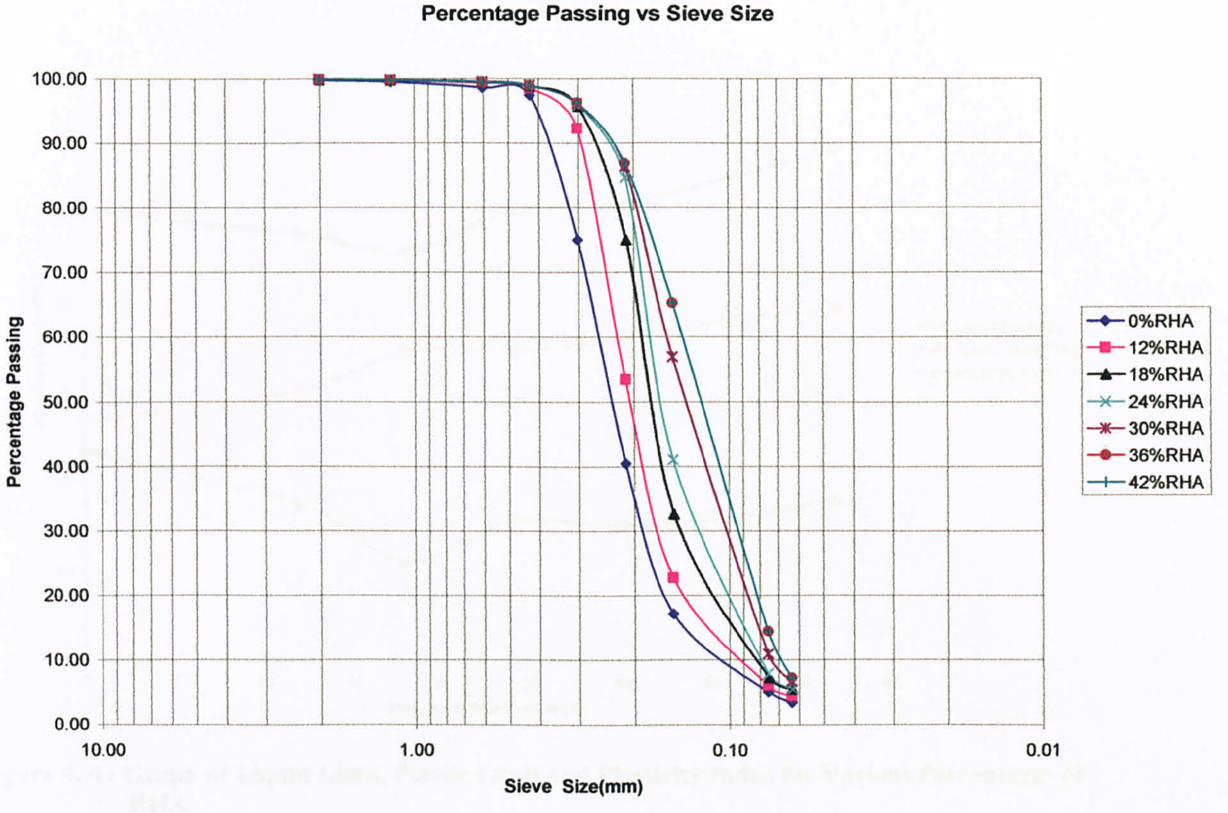

Figure 4. 3 : Particle size distribution of soil with various percentages of RHA

Figure 4.3 shows particle size distribution for various percentage of RHA with soil. The raw soil sample is poorly graded while the curves with more percentage of RHA have well graded particle distribution. It also indicated that the fines RHA would fill in the intervoid of the granulated soil particles that further improve the soil particle distribution.

4.4 Effect of Various Percentages of RHA on Atterberg's Limit

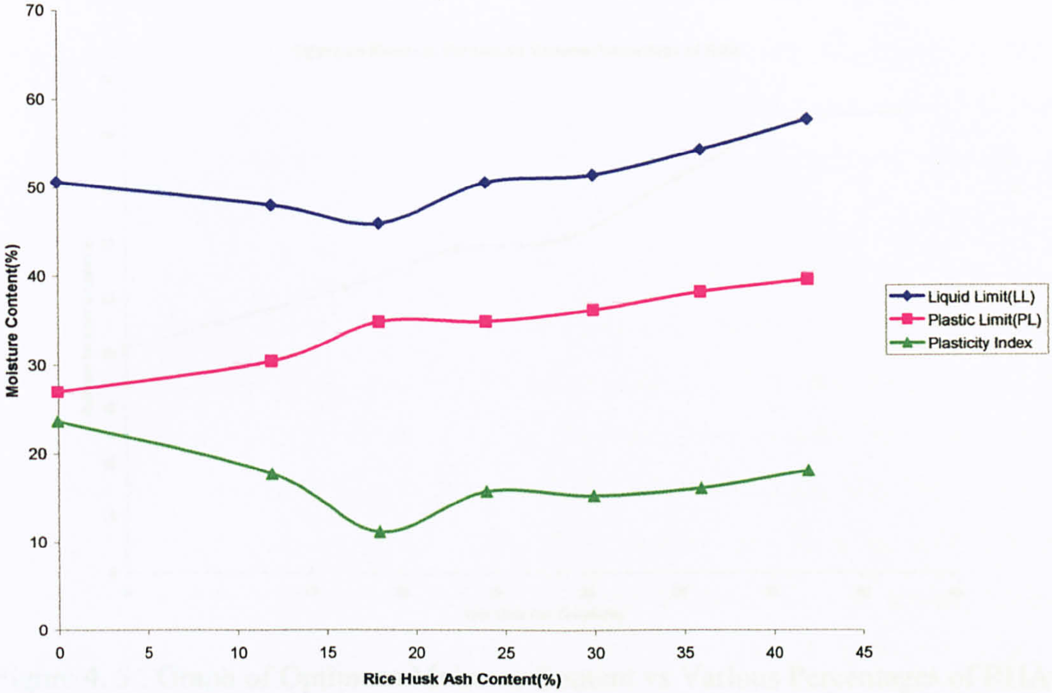

Figure 4. 4 : Graph of Liquid Limit, Plastic Limit and Plasticity Index for Various Percentages of RHA

Figure 4.4 shows the effect of various percentage of RHA to liquid limit and plasticity index of the soil. The plasticity index shows a reduction as liquid limit and plastic limit increase. It can be observed that soil with 18% to 24% RHA showed the lowest plasticity index. Low plasticity index indicated improvement of the soil behavior. The changes are caused by the fines RHA that fill in the intervoid of the granulated soil particles.

(Refer to Appendix B for Details Results of Liquid Limit Test for the Soil and RHA Mixed)

4.5 Effect of Various Percentages of RHA on Compaction Characteristic

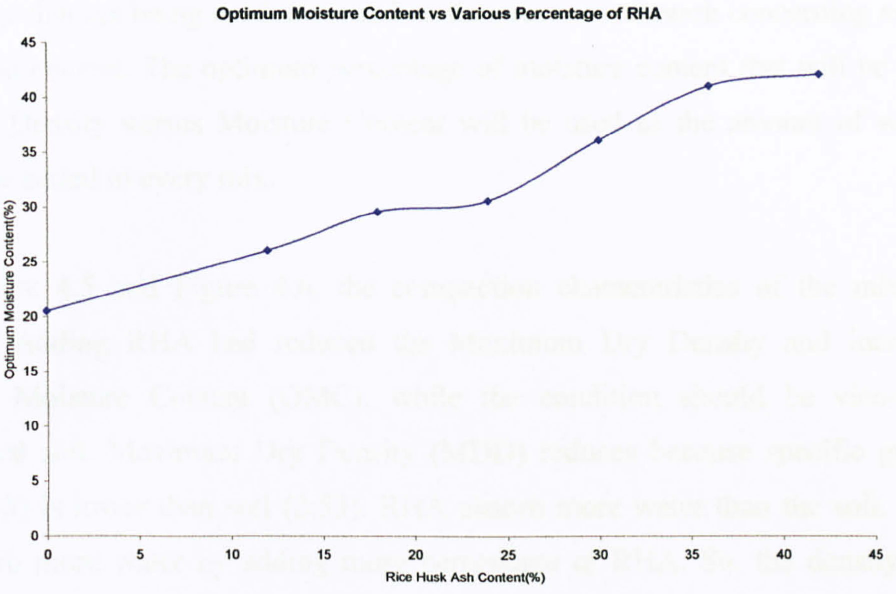

Figure 4. 5 : Graph of Optimum Moisture Content vs Various Percentages of RHA

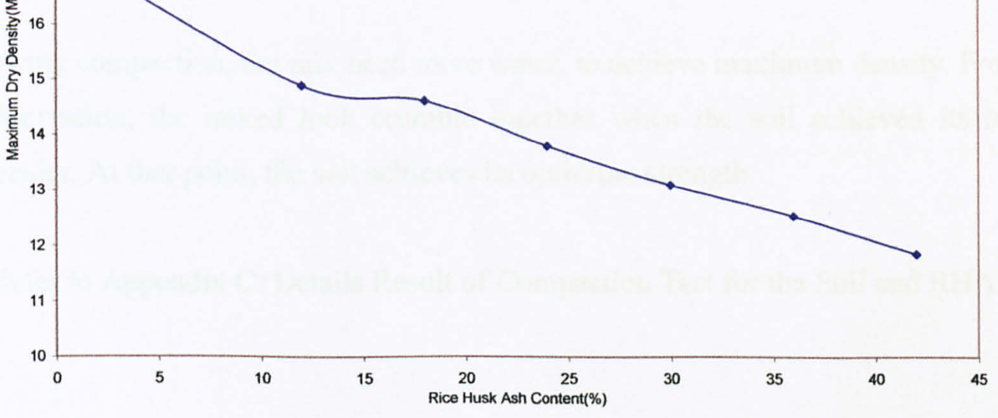

Figure 4. 6 : Maximum Dry Density vs Various Percentages of RHA

Proctor Compaction Test had been carried out to determine the optimum water content that need to be mixed with the RHA and soil. The percentage of water: 9%-54% had been mix with RHA: 12%, 18%, 24%, 30%, 36%, 42% and soil. The percentages of water range that are being used are based on the previous research concerning no adding of lime and cement. The optimum percentage of moisture content that will be obtained from Dry Density versus Moisture Content will be used as the amount of water that needs to be added in every mix.

From Figure 4.5 and Figure 4.6, the compaction characteristics of the mix can be observed. Adding RHA had reduced the Maximum Dry Density and increase the Optimum Moisture Content (OMC), while the condition should be vice-versa in unstabilized soil. Maximum Dry Density (MDD) reduces because specific gravity of RHA (2.43) is lower than soil (2.53). RHA absorb more water than the soil. The mix will absorb more water by adding more percentage of RHA. So, the density reduces when more RHA is added. Ash raises air bubbles when mixed with soil. The mix between soil and RHA raises air bubbles. More air bubbles will result by adding more percentages of RHA. So, the density reduces when more RHA is added.

Optimum Moisture Content (OMC) increases due to reaction of the soil particles. When more percentage of RHA is added, the mix between RHA and soil need more water to be stabilized. So, the OMC increase when more percentage of RHA is added.

During compaction, the mix need more water, to achieve maximum density. From naked observation, the mixed look crumble together when the soil achieved its maximum density. At that point, the soil achieves its optimum strength.

(Refer to Appendix C: Details Result of Compaction Test for the Soil and RHA Mixed)

4.6 Effect of Various Percentages of RHA on Compressibility Characteristic

4.6.1 Effect of Various Percentages of RHA on Compression Index, C_c

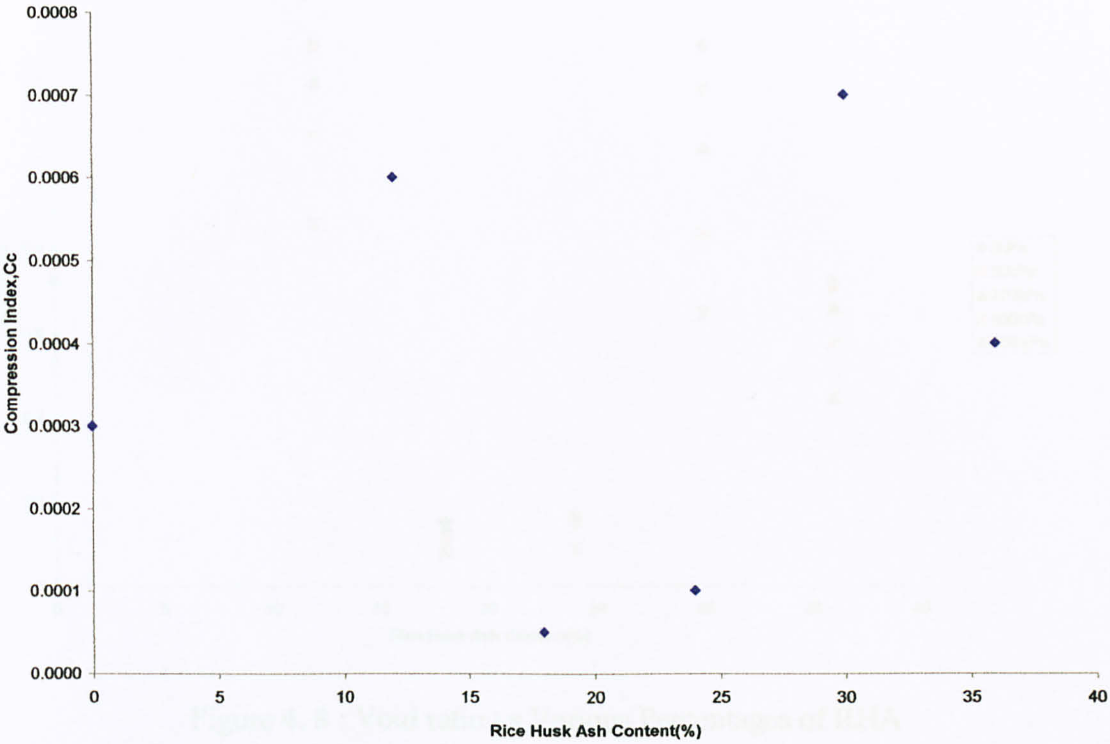

Figure 4. 7 : Compression Index vs Various Percentages of RHA

Figure 4.7 shows the relationship of compression index with various percentages of RHA. The void ratio decrease when 18% to 24% RHA is added. This indicated that more water dissipated and more pore reduction when 18% to 24% of RHA is added. The percentage of Compression Index reduction is 33% from unstabilized that is from 0.0003 to 0.0001.

4.6.2 Effect of Various Percentages of RHA on Void Ratio, *e*

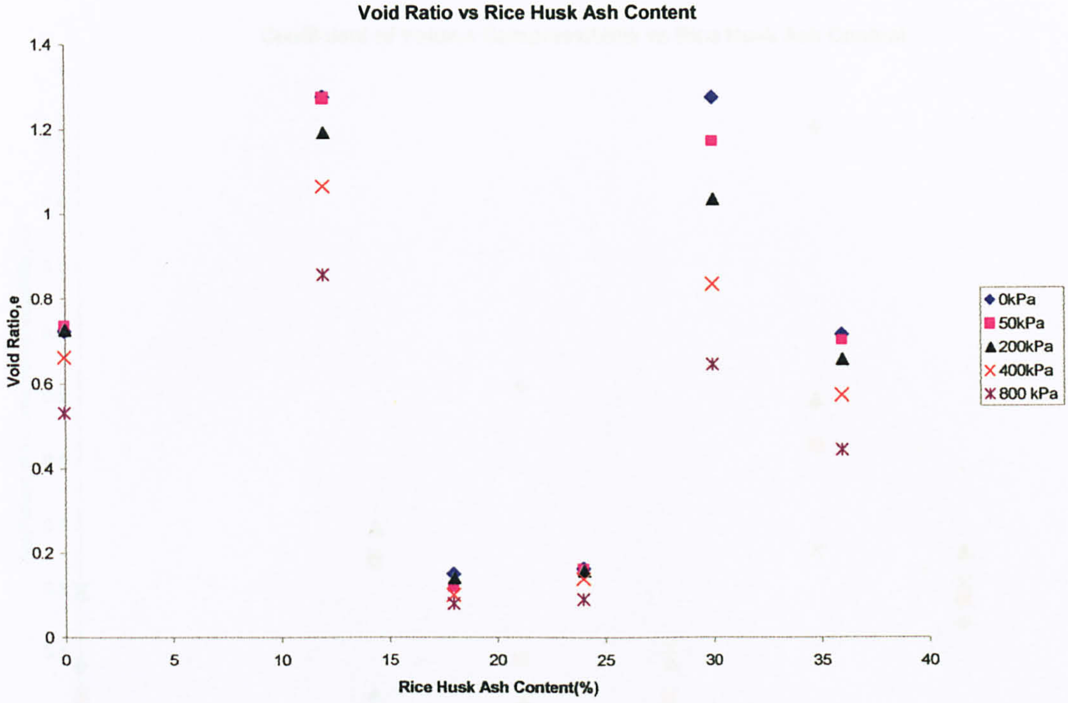

Figure 4. 8 : Void ratio vs Various Percentages of RHA

Figure 4.8 shows relationship of void ratio with various RHA percentages. From the figure, the void ratio decrease when 18% to 24% RHA is added. When 800 kPa stresses is applied, it will give most significant impact to the soil, the void ratio decreases from 0.531 to 0.09 when 18%-24% RHA is added. The void reduces almost 16.9% from unstabilized soil that is 0% of RHA. The void ratio reduces significantly because the RHA had prepared better drainage and increases the permeability of the soil. The RHA had fill the void of the soil particle.

4.6.3 Effect of Various Percentages of RHA on Coefficient of Volume Compressibility

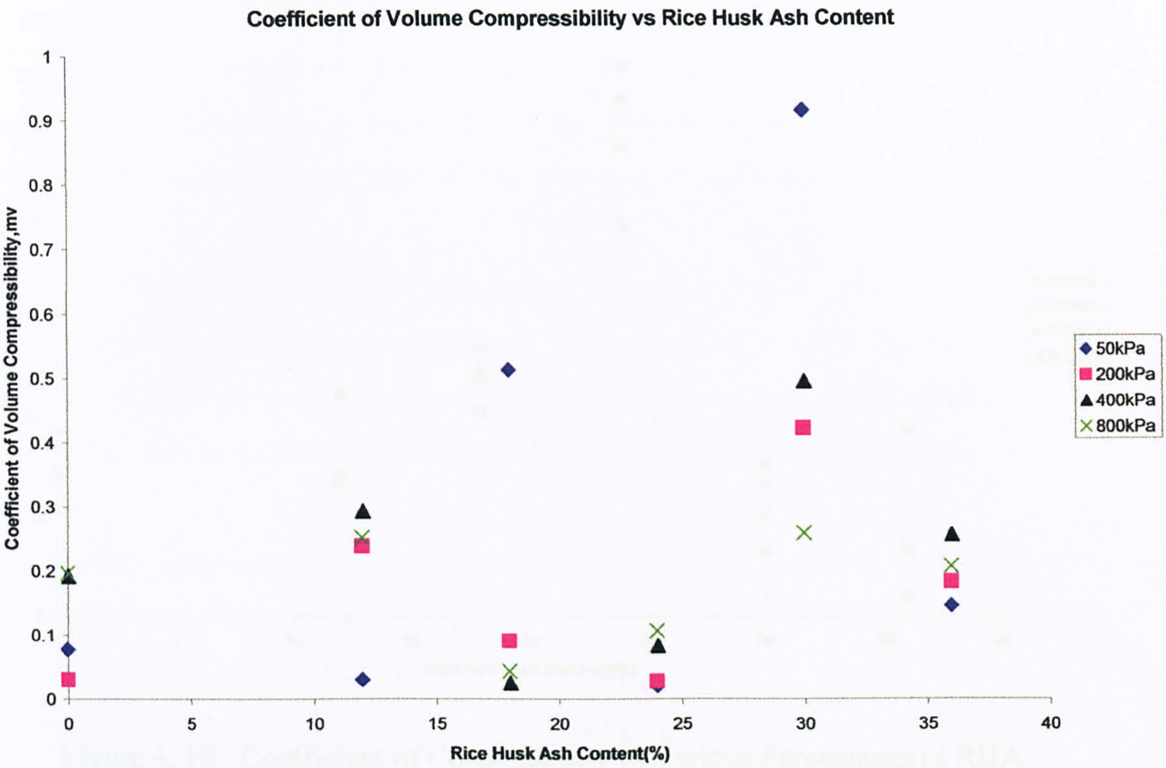

Figure 4. 9 : Coefficient of Volume Compressibility vs Various Percentages of RHA

Figure 4.9 shows the relationship of Coefficient of Volume Compressibility with various percentages of RHA. The void ratio decrease when 18% to 24 % RHA is added. When 800 kPa stresses is applied to the soil, the Coefficient of Volume Compressibility decrease from 0.196 to 0.106 when 18% to 24% RHA is added. The soils settle more when 18% to 24% of RHA is added.

4.6.4 Effect of Various Percentages of RHA on Coefficient of Consolidation

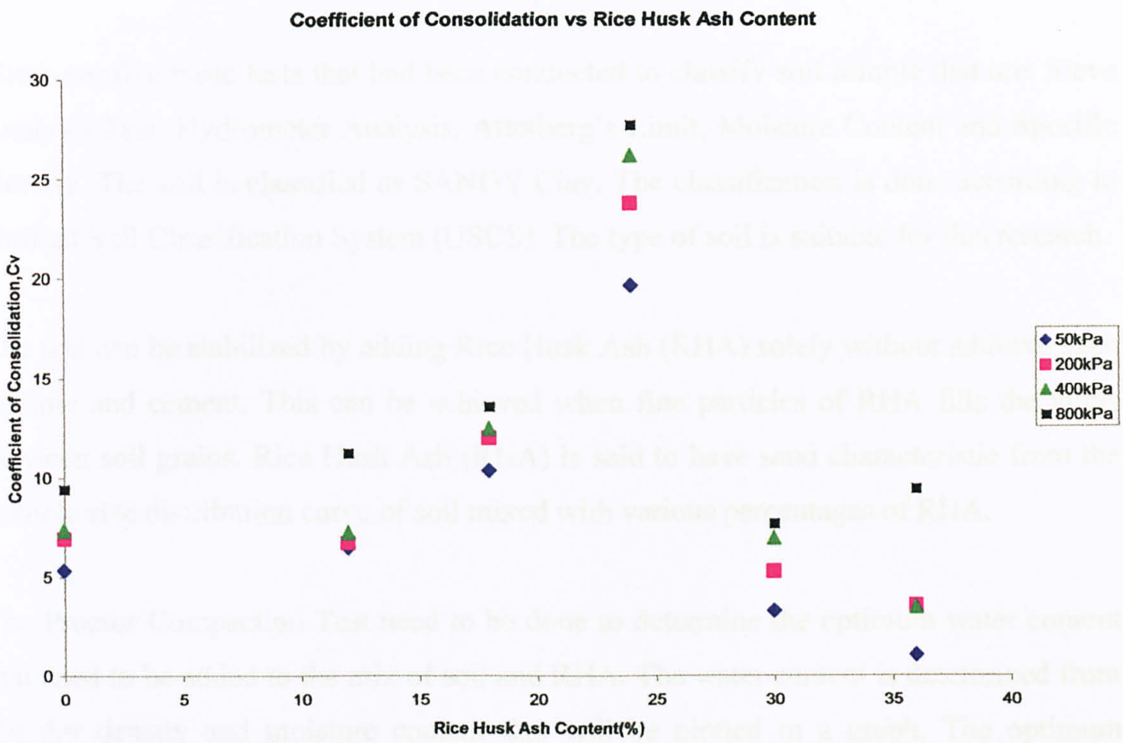

Figure 4. 10 : Coefficient of Consolidation vs Various Percentages of RHA

Figure 4.10 shows the relationship of Coefficient of Consolidation with various percentages of RHA. The void ratio decrease when 18 % to 24% RHA is added. When 800 kPa stresses is subjected to the soil, it will give most significant impact to the soil, the Coefficient of Consolidation increase from 9.422 mm^2/min to 27.685 mm^2/min when 18% to 24% of RHA is added. Based on equation (2.9), C_v is inversely proportional from time of consolidation. When 18% to 24% of RHA is added the time for consolidation reduces which is good for construction. The time for consolidation reduces as the soils behave like sand when more percentage of RHA is added.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

There are five basic tests that had been conducted to classify soil sample that are: Sieve Analysis Test, Hydrometer Analysis, Atterberg's Limit, Moisture Content and Specific Gravity. The soil is classified as SANDY Clay. The classification is done according to Unified Soil Classification System (USCS). The type of soil is suitable for this research.

The soil can be stabilized by adding Rice Husk Ash (RHA) solely without additive such as lime and cement. This can be achieved when fine particles of RHA fills the voids between soil grains. Rice Husk Ash (RHA) is said to have sand characteristic from the particle size distribution curve of soil mixed with various percentages of RHA.

The Proctor Compaction Test need to be done to determine the optimum water content that need to be added to the mix of soil and RHA. The water content is determined from the dry density and moisture content that will be plotted in a graph. The optimum percentage of moisture content will be taken as the amount of water added depends on the percentage of RHA. The compaction characteristic can be seen when Maximum Dry Density (MDD) decrease while Optimum Moisture Content (OMC) increase because of the reaction in the mix. The compaction curve have two peaks that proves the soil mixed with various percentages of RHA have the characteristic of sand.

The compressibility reduces when 18% to 24% RHA is added to the soil. When 800 kPa stresses is applied to the soil:

(a) Void ratio, e decrease from 0.531 to 0.09 that is 16.9% reduction
(b) Compression Index, C_c decrease from 0.0003 to 0.0001 that is 33% reduction
(c) Coefficient of Consolidation, C_v increase from 9.422 mm^2/min to 27.685 mm^2/min
(d) Coefficient of Compressibility, m_v decrease from 0.196 to 0.106

For site application, the RHA can be applied by grouting, the same method that being applied for lime-RHA and cement.

For further studies, the RHA should be mixed with other types of soil especially clay to see the significant improvement of compressibility characteristics. It is also suggested that the soil from Changkat Cermin, Perak to be mixed with lime-RHA to see the difference between adding solely RHA and lime-RHA from economic and performance view.

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APPENDICES

APPENDIX A:

Details of Lab testing for Soil and RHA

Physical Properties

Appendix A1: Sieve Analysis Test and Hydrometer Test

Table A1 : Sieve Analysis

Sieve No	Opening (mm)	Mass of Empty Sieve (g)	Mass Sieve + Soil Retained (g)	Mass Retained (g)	% Retained	Cummulative % Retained	% Passing
10.00	2.00	454.80	455.30	0.50	0.25	0.25	99.75
16	1.180	425.80	426.30	0.50	0.25	0.50	99.50
30	0.600	405.30	407.10	1.80	0.90	1.41	98.59
40	0.425	365.70	368.20	2.50	1.26	2.66	97.34
50	0.300	369.70	414.10	44.40	22.32	24.99	75.01
70	0.212	343.10	411.90	68.80	34.59	59.58	40.42
100	0.150	347.90	394.20	46.30	23.28	82.86	17.14
200	0.075	254.30	278.40	24.10	12.12	94.97	5.03
	0.063	328.10	331.30	3.20	1.61	96.58	3.42
Pan	-	394.40	401.20	6.80	3.42	100.00	0.00
Total				198.90	100.00		

Table A.2 : Hydrometer General Information

Specific Gravity(Gs):	2.53	Dry weight of Specimen(g):		50
Temperature (C):	26	Hydrometer type:		151 - H
Meniscus Correction:	0.005	Zero Correction:		1
K factor	0.01257	Gs correction factor:		1.028
		Temp correction factor:		1.21

Table A3 : Test Data of Hydrometer Analysis

Time	Actual Hydrometer Reading	Hydrometer Correction for Meniscus	Effective Length	D mm	Hydrometer Correction R_C	% finer P	& adjusted finer P_A
0.5	1.0300	1.0300	7.00	0.04703	2.2400	4.6054	4.1403
1	1.0300	1.0300	7.30	0.03396	2.2400	4.6054	4.1403
2	1.0280	1.0280	7.65	0.02458	2.2380	4.6013	4.1366
4	1.0270	1.0270	8.35	0.01816	2.2370	4.5993	4.1347
8	1.0260	1.0260	9.05	0.01337	2.2360	4.5972	4.1329
30	1.0240	1.0240	9.85	0.00720	2.2340	4.5931	4.1292
120	1.0210	1.0210	10.50	0.00372	2.2310	4.5869	4.1237
480	1.0190	1.0190	11.00	0.00190	2.2290	4.5828	4.1200
1440	1.0170	1.0170	11.40	0.00112	2.2270	4.5787	4.1163

Appendix A2: Atterberg's Limit Test

Table A4 : Liquid Limit

Test No	1		2		3	
Initial dial gauge reading (mm)	0.00	0.00	0.00	0.00	0.00	0.00
Final dial gauge reading (mm)	16.20	16.30	18.40	18.30	21.50	22.00
Average Penetration (mm)	16.25		18.35		21.75	
Container No.	1		2		3	
Mass of wet soil + container (g)	57.43		53.14		58.77	
Mass of dry soil + container (g)	51.06		45.39		48.61	
Mass of container (g)	37.29		29.54		29.32	
Mass of moisture (g)	6.37		7.75		10.16	
Mass of dry soil (g)	13.77		15.85		19.29	
Moisture content %	46.26		48.90		52.67	

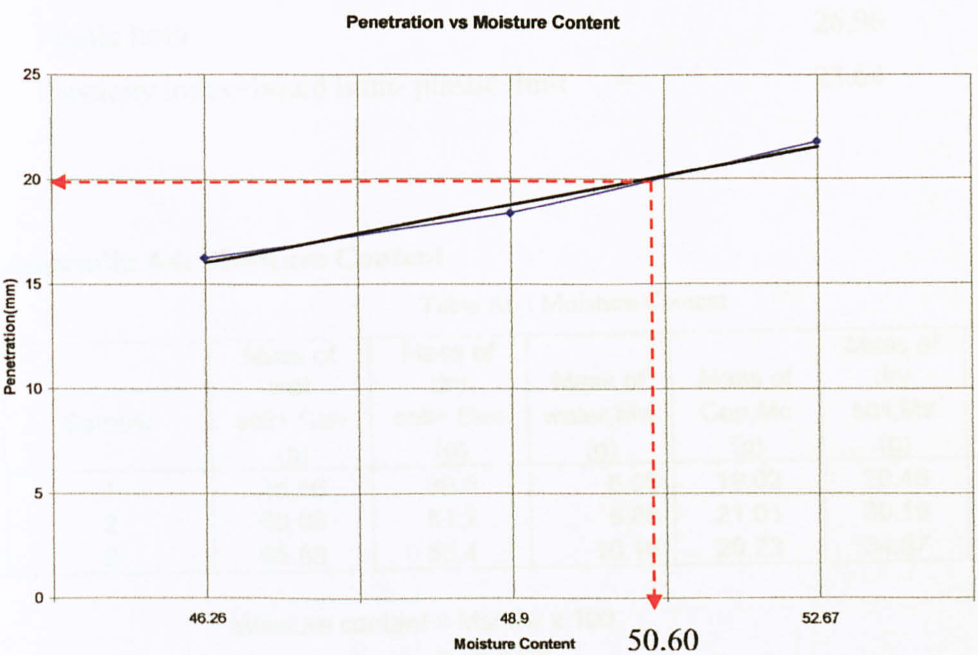


Figure A1 : Typical Graph of Cone Penetration vs Moisture Content

Appendix A3: Plastic Limit and Plasticity Index of Soil

Table A5 : Plastic Limit

Can no.	1	2
Mass of can+moist soil,Mcws(g)	42	48.9
Mass of can+dry soil,Mcs(g)	39.29	46.58
Mass of can,Mc(g)	29.28	37.94
Mass of water,Mw(g)	2.71	2.32
Mass of dry soil,Ms(g)	10.01	8.64
Water content,w(%)	27.07	26.85
Plastic limit(%)	26.96	

Liquid limit = 50.60

Plastic limit = 26.96

Plasticity index=liquid limit- plastic limit = 23.64

Appendix A4: Moisture Content

Table A6 : Moisture Content

Sample	Mass of wet soil+ Can (g)	Mass of dry soil+ Can (g)	Mass of water,Mw (g)	Mass of Can,Mc (g)	Mass of dry soil,Ms (g)	Moisture content, w %
1	45.56	39.5	6.06	19.02	20.48	29.59
2	60.08	51.2	8.88	21.01	30.19	29.41
3	65.56	55.4	10.16	20.73	34.67	29.30

Moisture content = Ms/Mw x 100
= 29.43%

Appendix A5: Specific Gravity of Soil

Table A7 : Specific Gravity of Soil

Jar no.		Unit	**1.00**	**2.00**	**3.00**
Mass of jar + gas jar + plate	(m1)	(g)	532.80	537.60	535.90
Mass of jar + gas jar + plate + soil	(m2)	(g)	932.90	938.90	936.00
Mass of jar + gas jar + plate + soil + water	(m3)	(g)	1795.71	1805.67	1788.10
Mass of jar + gas jar + plate + water	(m4)	(g)	1557.28	1547.06	1562.00
Mass of soil	(m2-m1)	(g)	400.10	401.30	400.10
Mass of water in full jar	(m4-m1)	(g)	1024.48	1009.46	1026.10
Mass of water used	(m3-m2)	(g)	862.81	866.77	852.10
Volume of soil particles	(m4-m1) - (m3-m2)	ML	161.67	142.69	174.00
Partcle density,ps		Mg/m^3	2.47	2.81	2.30
Average value, ps		Mg/m^3		2.53	

Appendix A6: Specific Gravity of Rice RHA

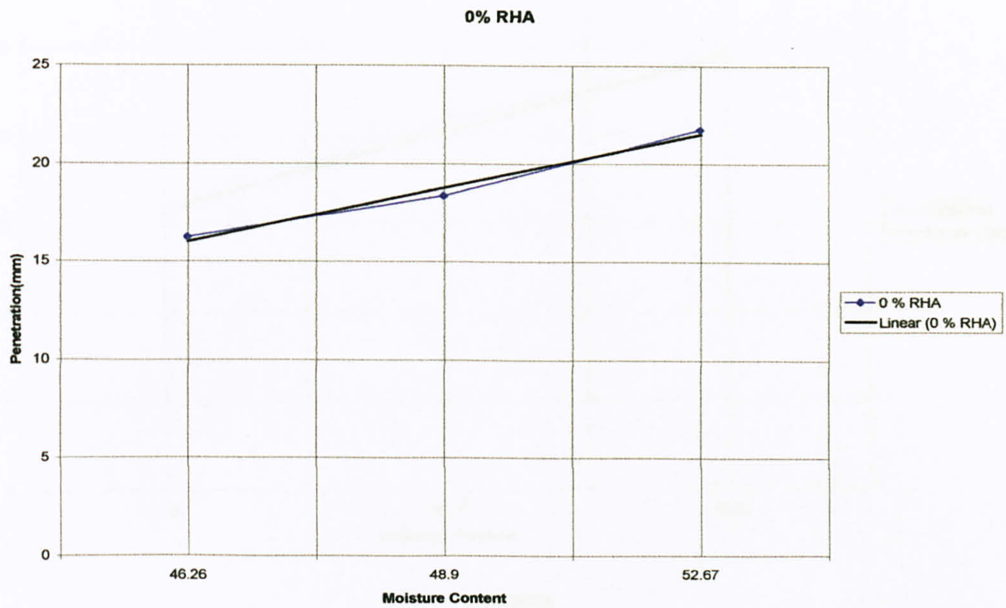
Table A8 : Specific Gravity of RHA

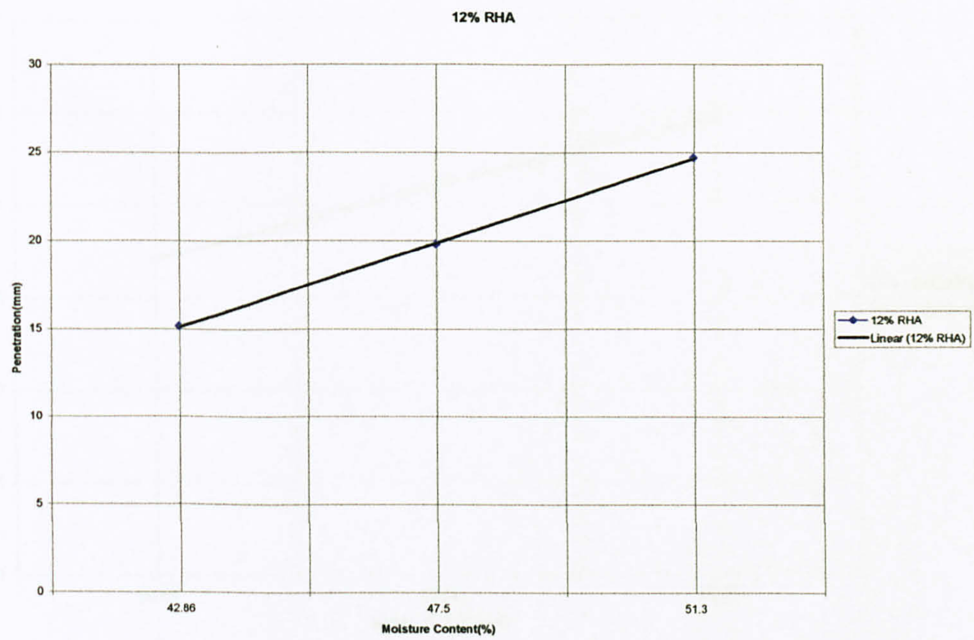
Jar no.			**1**	**2**
Mass of jar + gas jar + plate	(m_1)	(g)	534.29	537.28
Mass of jar + gas jar + plate + soil	(m_2)	(g)	934.14	937.34
Mass of jar + gas jar + plate + soil + water	(m_3)	(g)	1720.41	1720.82
Mass of jar + gas jar + plate + water	(m_4)	(g)	1449.97	1546.77
Mass of soil	$(m_2 - m_1)$	(g)	399.85	400.06
Mass of water in full jar	$(m_4 - m_1)$	(g)	915.68	1009.49
Mass of water used	$(m_3 - m_2)$	(g)	786.27	783.48
Volume of soil particles	$(m_4 - m_1) - (m_3 - m_2)$	ML	129.41	226.01
Particles density, ρ_s		Mg/m^3	3.09	1.77
Particles density, ρ_s		Mg/m^3	2.43	

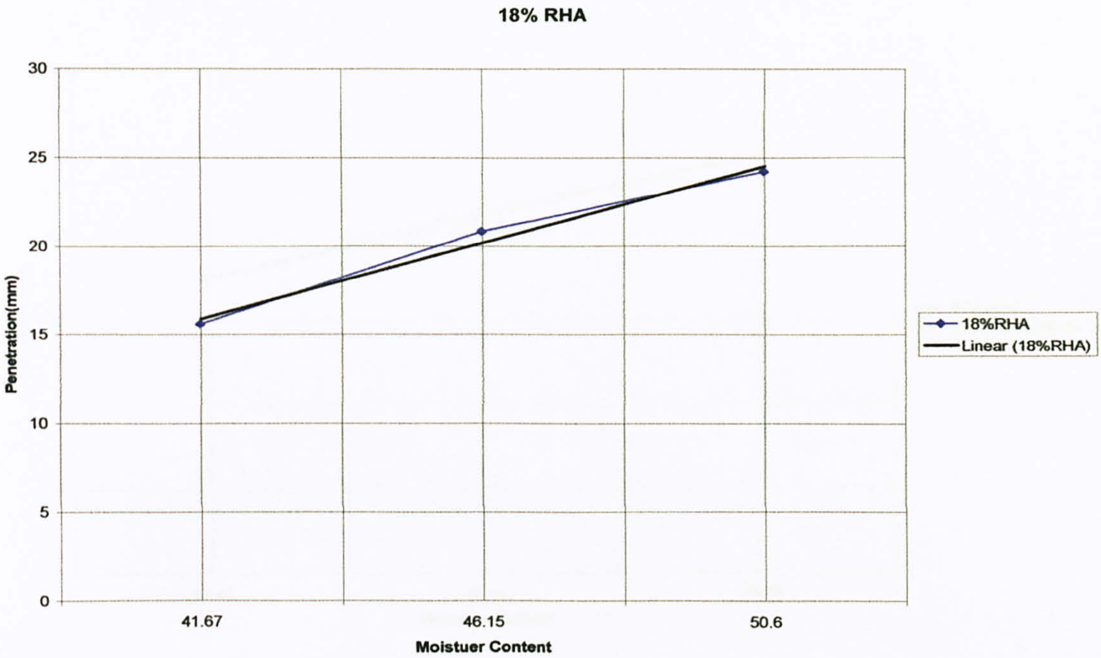
APPENDIX B:

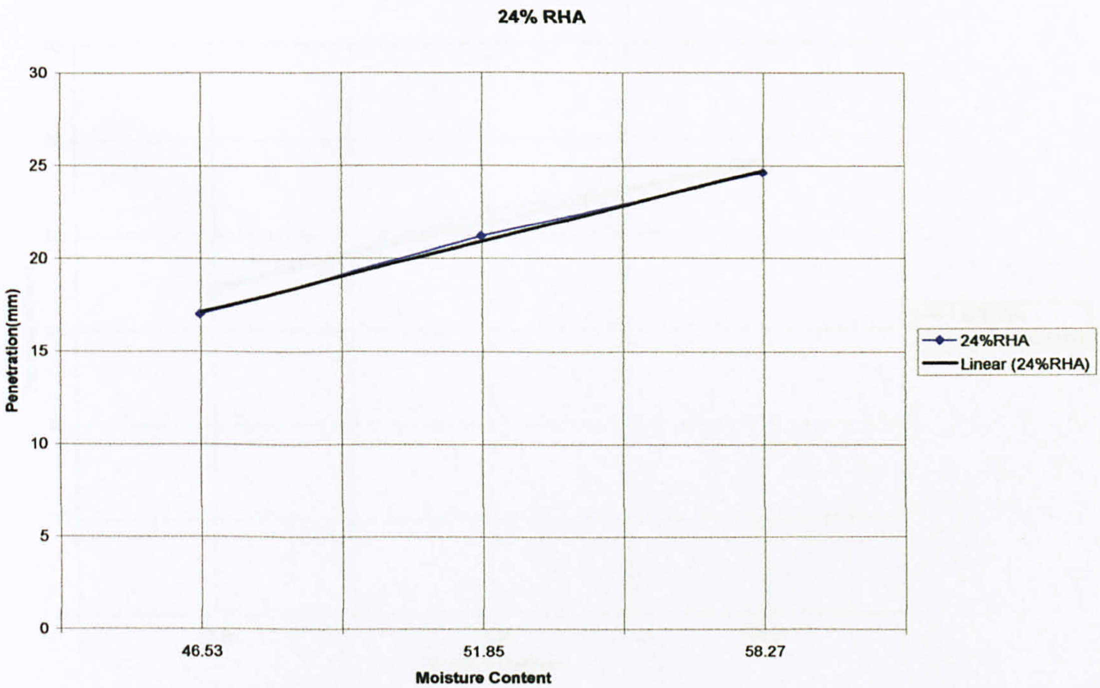
Details Result of Liquid Limit Test for the Soil and RHA Mixed

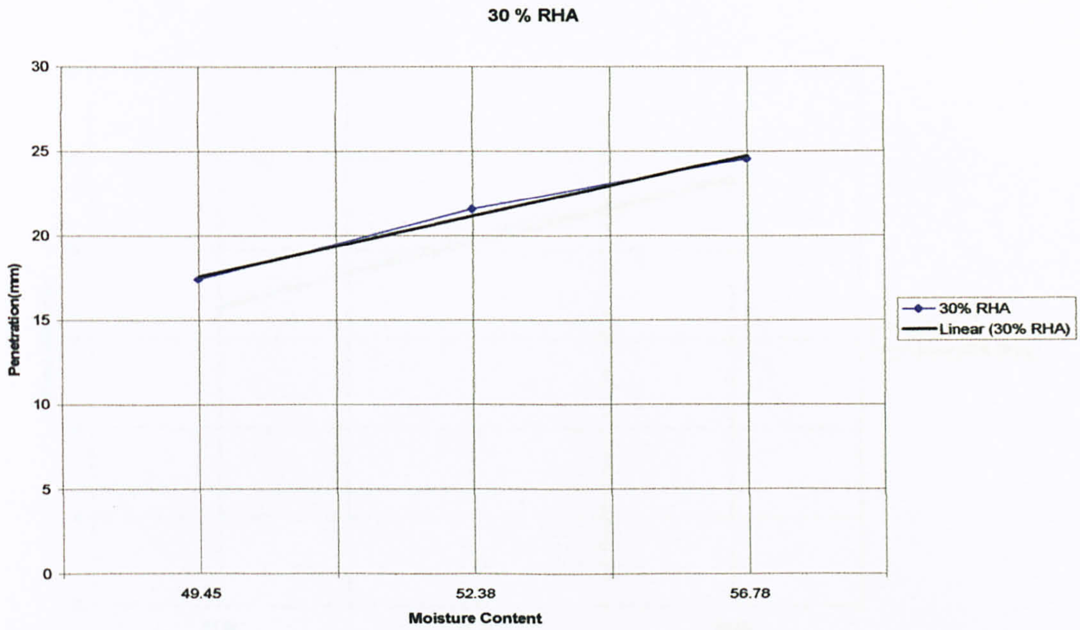
Appendix B: Atterberg's Limit (Liquid Limit Test)

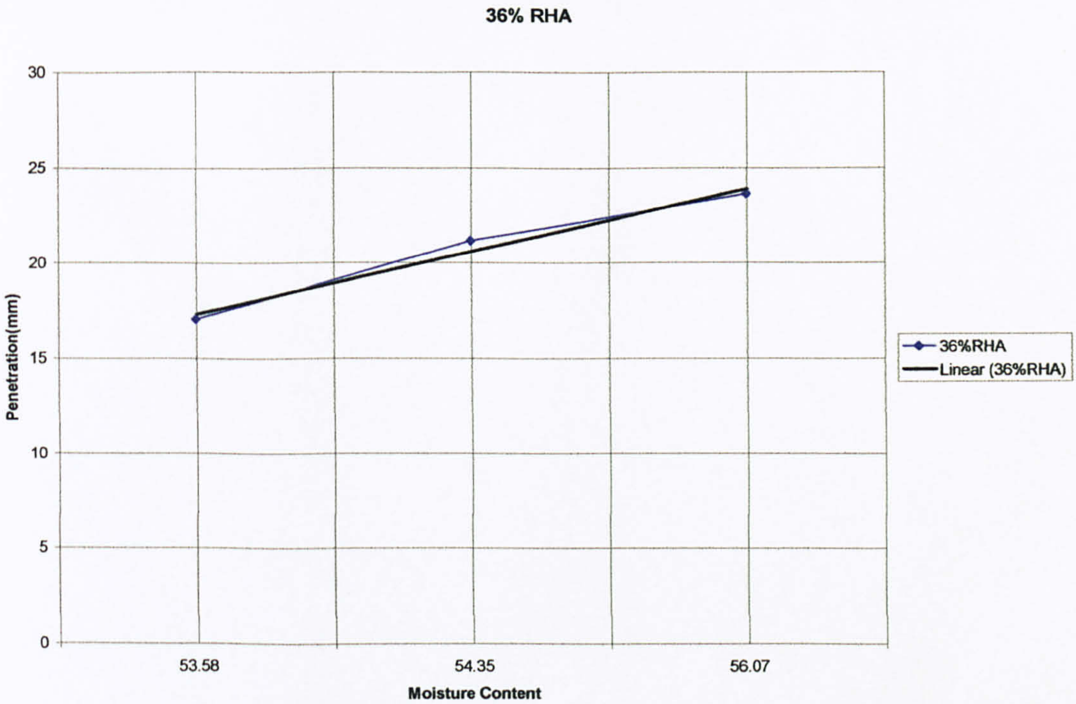


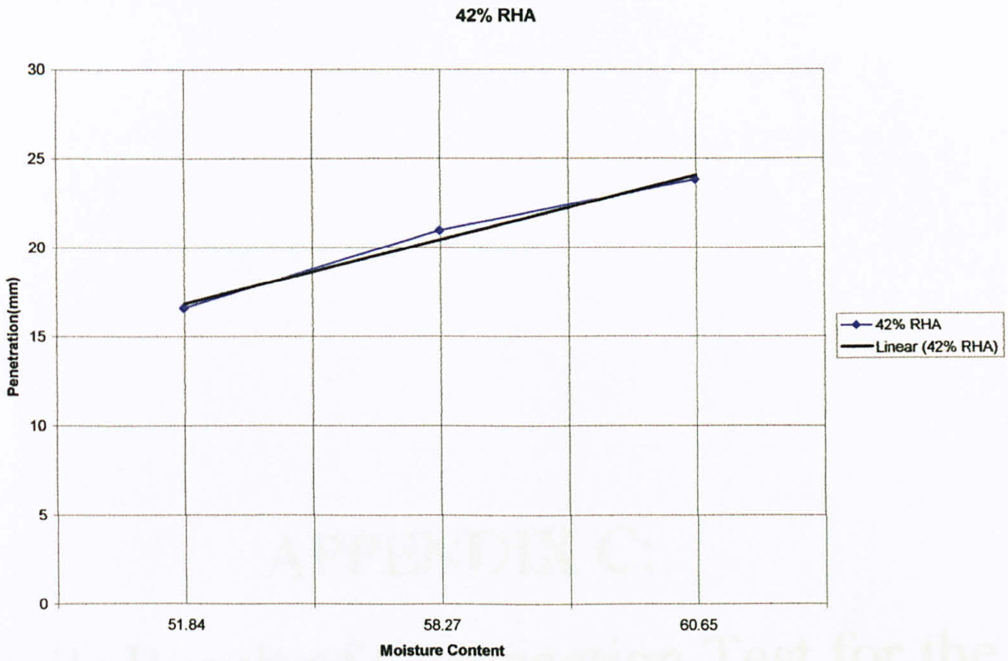



18% RHA
30
25
20
15
10
5
0
Penetration(mm)
41.67
46.15
50.6
Moistuer Content
18%RHA
Linear (18%RHA)


24% RHA
30
25
20
15
10
5
0
Penetration(mm)
46.53
51.85
58.27
Moisture Content
24%RHA
Linear (24%RHA)


30 % RHA
Penetration(mm)
Moisture Content
30
25
20
15
10
5
0
49.45
52.38
56.78
30% RHA
Linear (30% RHA)

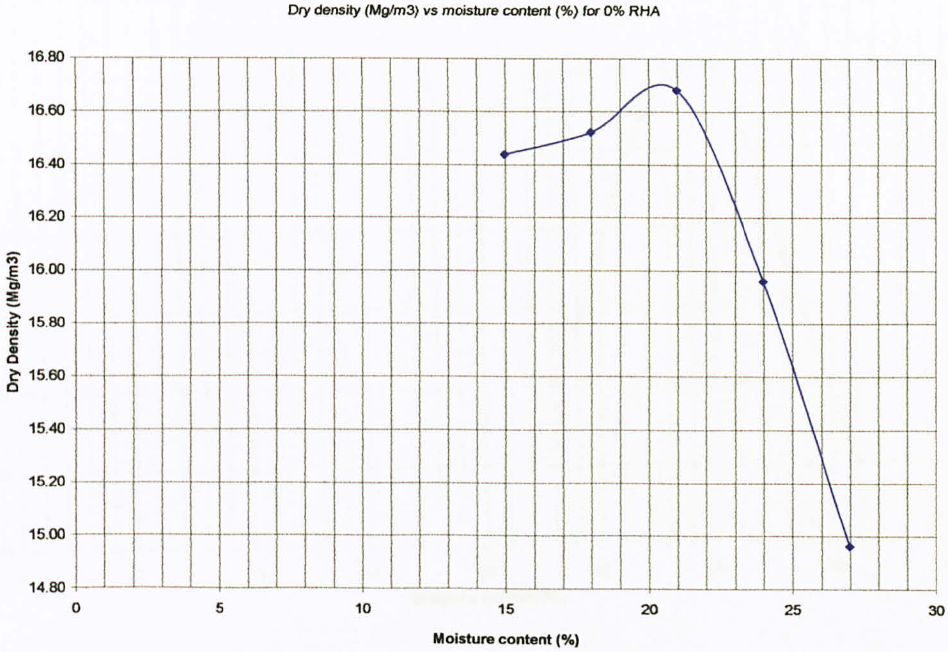

36% RHA
Penetration(mm)
Moisture Content
30
25
20
15
10
5
0
53.58
54.35
56.07
36%RHA
Linear (36%RHA)

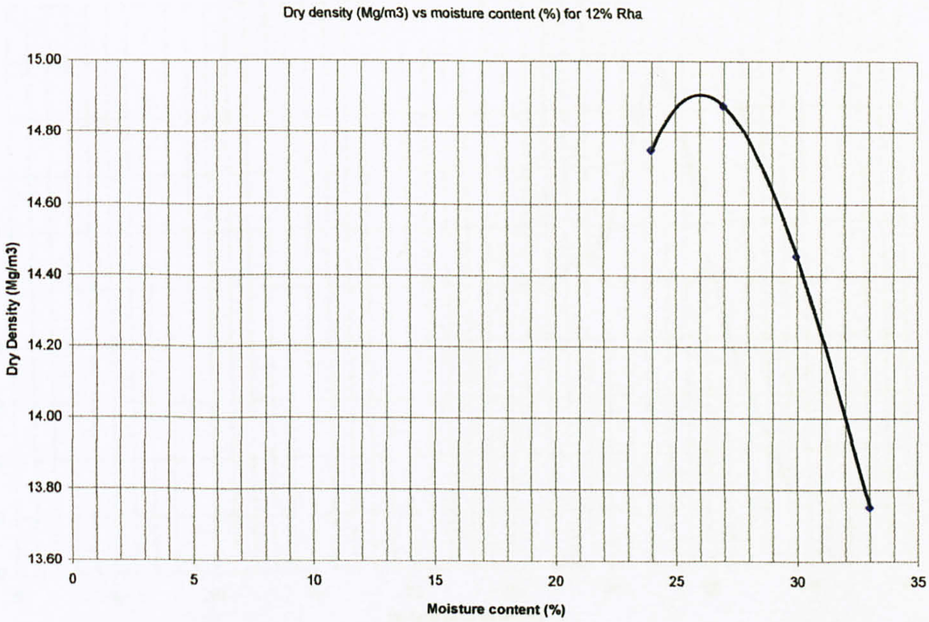

42% RHA
Penetration(mm)
Moisture Content
0
5
10
15
20
25
30
51.84
58.27
60.65
42% RHA
Linear (42% RHA)

APPENDIX C:

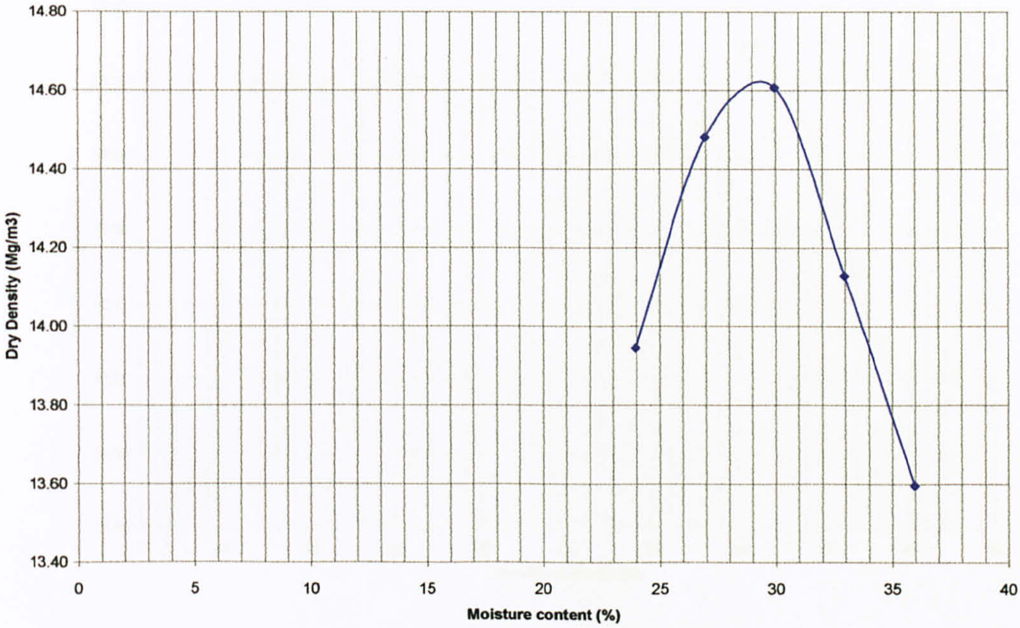
Details Result of Compaction Test for the Soil and RHA Mixed

Appendix C: Compaction Test

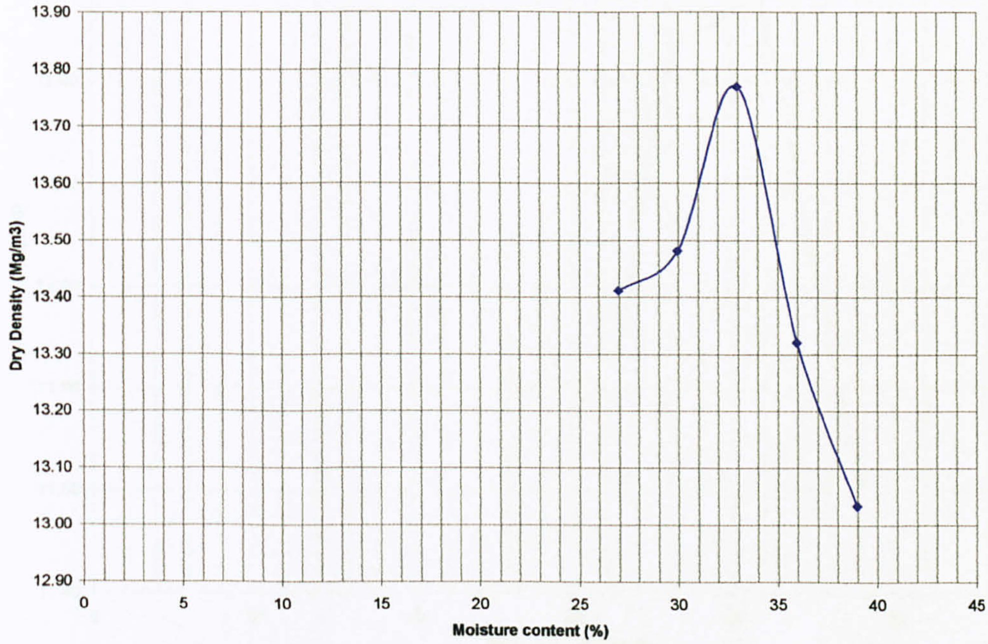




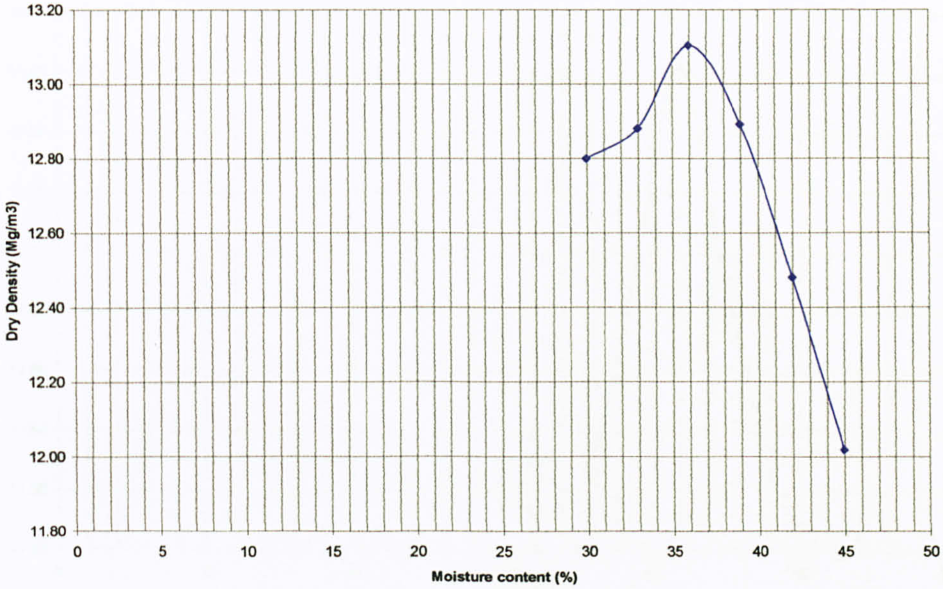
Dry density (Mg/m3) vs moisture content (%) for 18% Rha



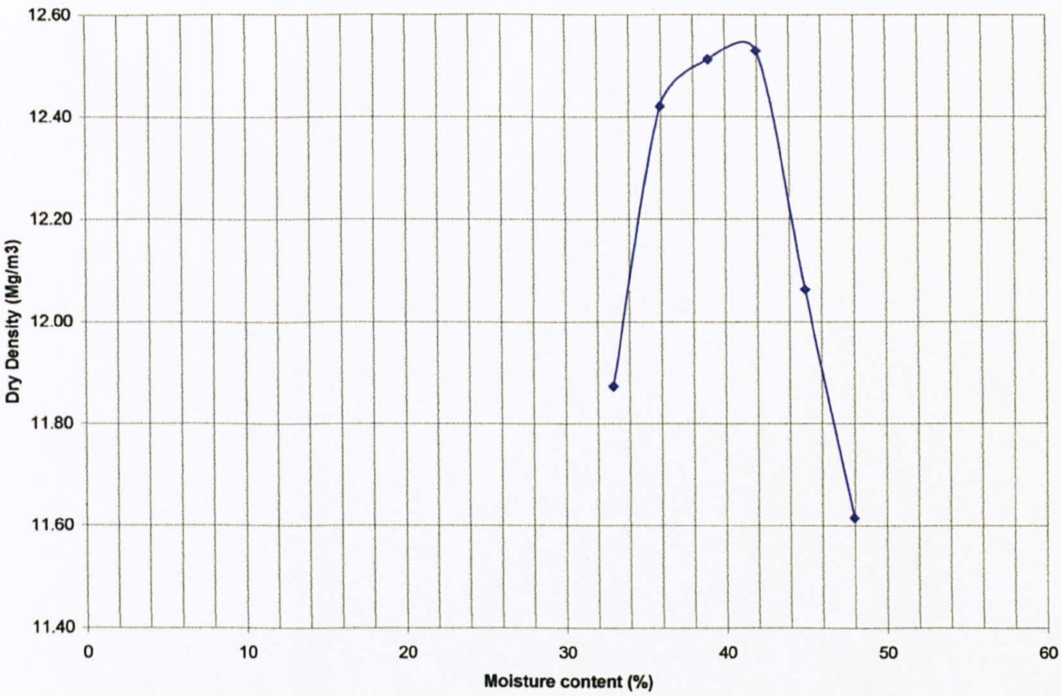
Dry density (Mg/m3) vs moisture content (%) for 24% RHA

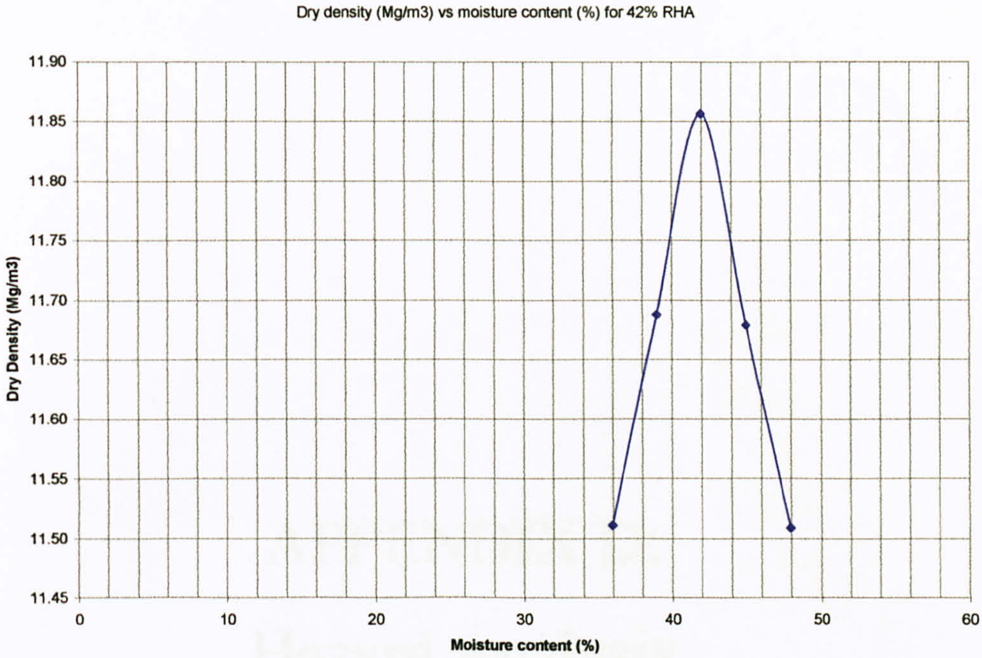


Dry density (Mg/m3) vs moisture content (%) for 30% RHA



Dry density (Mg/m3) vs moisture content (%) for 36% Rha





Dry density (Mg/m3) vs moisture content (%) for 42% RHA
Dry Density (Mg/m3)
11.90
11.85
11.80
11.75
11.70
11.65
11.60
11.55
11.50
11.45
0
10
20
30
40
50
60
Moisture content (%)

APPENDIX D:

Hazard Analysis

Appendix D1: Sample Handling

Soil Sample

Person exposed to hazard : Technologist, Student

Location : 14-00-11

Section/Lab : Geotechnical Lab

Sequence of Basic Job Procedures	Hazards	Safe Job Procedure
1. Grind the sample.	• Expose to dust	• Wear protective mask
2. Using the sample for lab testing.	• Expose to dust	• Wear protective mask

Rice Husk Ash (RHA) Sample

Person exposed to hazard : Technologist, Student

Location : 14-00-11 and Block J

Section/Lab : Geotechnical Lab and Concrete Lab

Sequence of Basic Job Procedures	Hazards	Safe Job Procedure
1. Burn Rice Husk in the incinerator	• Expose to dust and heat	• Wear protective mask and protective gloves
2. Grind the sample.	• Expose to dust	• Wear protective mask
3. Use the sample for lab testing.	• Expose to dust	• Wear protective mask

Appendix D2: Lab Equipment Handling

Sieve Shaker Set

Person exposed to hazard : Technologist, Student

Location : 14-00-11

Section/Lab : Geotechnical Lab

Sequence of Basic Job Procedures	Hazards	Safe Job Procedure
1. Arrange the sieves according to the size. Put the soil sample in the sieves.	• Expose to dust	• Wear protective mask
2. Put the complete set of the sieve on the base of the shaker.		
3. Tighten the locknut and set the timer.	• Blockade fingers	• Wear protective glove
4. Switch on the machine and wait for set up timing.	• Electrical shock	• Wear protective glove
5. Switch off the machine.		
6. Loosen the locknut on the nylon headed bolt and pull up the shaker cover.	• Blockade fingers	• Wear protective glove
7. Remove the complete unit of sieving from the machine.		
8. House keeping.		

Hydrometer Test

Person exposed to hazard : Technologist, Student

Location : 14-00-11

Section/Lab : Geotechnical Lab

Sequence of Basic Job Procedures	Hazards	Safe Job Procedure
1. Filled the tank with water until reach required level.	• Water spill on the table	• Used proper rubber tube • Not used high pressure water inlet
2. Switch on the power supply.	• Electrical shock	• Used proper glove
3. Set the temperature.		
4. Put the sample cylinder inside the tank.	• Water spill on the table	• Do not filled too much water in the tank
5. Left the sample 24 hours for test.		
6. Switch off the power supply.	• Electrical shock	• Used protective glove
7. Remove sample and water inside the tank and clean it up.		

Cone Penetrometer

Person exposed to hazard : Technologist, Student

Location : 14-00-11

Section/Lab : Geotechnical Lab

Sequence of Basic Job Procedures	Hazards	Safe Job Procedure
1. With the penetrometer cone locked in the raised position.		
2. Lower the supporting assembly so that tip of cone touches the soil surface.	• Blockade finger	• Used protective glove
3. Set the timer to 5seconds		
4. Press the releases button after 5seconds the controller will lock the cone shaft.	• Blockade finger	• Used protective glove
5. Lower the section rod until reach the supporting piston. Take the value of penetration.		

Mixer

Person exposed to hazard : Technologist, Student

Location : 14-00-11

Section/Lab : Geotechnical Lab

Sequence of Basic Job Procedures	Hazards	Safe Job Procedure
1. Filled the mixer bowl with sample.	• Exposed to the dust	• Wear protective mask
2. Install the bowl at fully lower bowl support.		
3. Place the agitator in the bowl, push it up on the agitator shaft and turn clockwise.	• Blockade fingers	• Wear protective glove
4. Move the gear shift lever to the desired speed and switch on the mixer to start operate.		
5. Switch off the power supply.	• Electrical shock	• Wear protective glove
6. Pulled down the bowl lift handle and move agitator. After that pulled out the bowl.	• Blockade fingers	• Wear protective glove
7. Clean the bowl and agitator.		

Compaction Test

Person exposed to hazard : Technologist, Student

Location : 14-00-11

Section/Lab : Geotechnical Lab

Sequence of Basic Job Procedures	Hazards	Safe Job Procedure
1. Locate centrally the mould at the base of compaction.	• The hammer drop	• Be ware of your hand
2. Fit the mould screw.	• The hammer drop	• Be ware of your hand
3. Put ¼ soil sample inside the mould.	• The hammer drop	• Used scoop to put soil
4. Press the start button.	• Noise come from the stamping of the hammer	• Use ear muff
5. Press stop button until reach 27 blows.		
6. Add more soil sample until 4 layers.	• The hammer drop	• Used scoop to add soil
7. After compaction, loch the safety key and remove the mould.		

Universal Extruder

Person exposed to hazard : Technologist, Student

Location : 14-00-11

Section/Lab : Foundation and Earth Structure Lab

Sequence of Basic Job Procedures	Hazards	Safe Job Procedure
1. Choose the suitable frame and plate.	• The frame drop	• Wear a protective shoes • Wear a protective gloves
2. Put the sample at the center of the extruder.	• The sample drop	• Wear a protective shoes • Wear a protective gloves
3. Pull up the extruder until the sample come out with hand handle.		
4. Remove the sample from the extruder.	• The sample drop	• Wear a protective shoes • Wear a protective gloves
5. Release the screw below to push down the extruder.	• The oil leaking	• Be ware during release the screw
6. Clean the equipment.		

Oedometer Test

Person exposed to hazard : Technologist, Student

Location : 14-00-09

Section/Lab : Foundation and Earth Structure Lab

Sequence of Basic Job Procedures	Hazards	Safe Job Procedure
1. Locate centrally the lower porous disc on the base of the cell.		
2. Fit the ring retainer and cell body around the ring.		
3. Add water into the cell.		
4. Add weight to the load hanger.	• The weights drop	• Wear a protective shoes
5. Place additional weights.	• The weights drop	• Wear a protective shoes
6. The graph computed by the computer.		
7. Wind up the support beam and take off the weights.	• The weights drop	• Wear a protective shoes

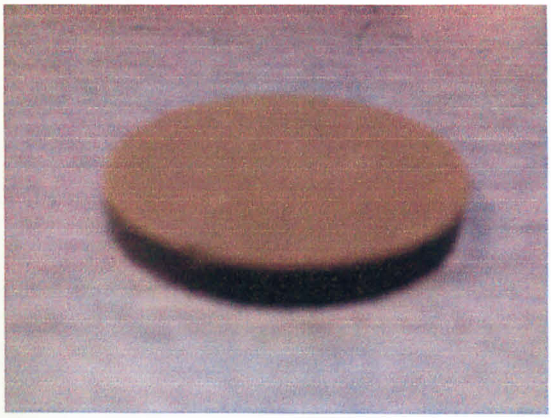
APPENDIX E:
Picture of Lab Works

Appendix E1:X-Ray Diffraction Test

Description : Waxed RHA

Date : 21 September 2007

Location : Geotechnical Lab



Description : Waxed Soil

Date : 25 September 2007

Location : Geotechnical Lab

Appendix E2: Sieve Analysis Test

Description : Sieve Shaker

Date : 3 October 2007

Location : Geotechnical Lab

Appendix E3: Specific Gravity Test

Description: Pycnometer filled with water and soil

Date : 3 October 2007

Location : Geotechnical Lab

Appendix E4: Plastic Limit Test

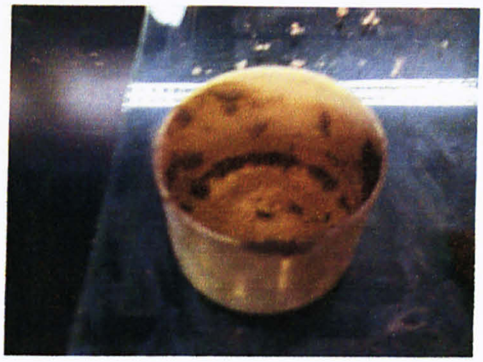
Description: Conducting the test

Date: 25 October 2007

Location : Geotechnical Lab

Appendix E5: Liquid Limit Test

Description: Penetrometer
Date : 25 October 2007
Location : Geotechnical Lab



Description: Container
Date : 25 October 2007
Location : Geotechnical Lab

Appendix E6: Crushing Soil

Description : Crushing Soil Work
Date : 6 November 2007
Location : Geotechnical Lab